COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

August 1954

Rouge Plant of Ford Motor Company, Dearborn, Michigan

Rouge Plant Modernizes Steam Generation

Determining Fly Ash Size Consist

Case History of a Topping Turbine

Current Status of Demineralizing

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Vol. 26 **No. 2**

August 1954

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HALL INDUSTRIAL WATER REPORT

Hall Laboratories, Inc.—A Subsidiary of Hagan Corporation, Pittsburgh, Pa.

Volume 2 AUGUST 1954 Number 4

Investigation from the Ground Up

A recent experience in a large utility plant took Hall Service engineer R. G. Hobek from the basement to the roof to investigate the connection between contaminated boiler water and a peculiar odor that was permeating the entire building.

The No. 2 unit of this plant is rated at 700,000 pounds per hour and is operated at 1500 pounds per square inch. Favorable operating conditions in the equipment at this power station are scrupulously maintained, so the plant men were disturbed when an unusual color showed up in water samples drawn from this boiler. At about the same time, a heavy odor became noticeable throughout the plant.

Mr. Hobek reports:

"We noted the heavy, sweet, organic odor as soon as we entered the building. When the boiler water was checked, it was found to contain a yellowish, well-dispersed material that would not settle, and could not be removed by ordinary filtration.

"We started our examination of the system at the condenser vacuum pump vent line in the basement where the odor was first noted. We followed the line to the roof where it exhausted. In observing the vent lines from the No. 1 and No. 2 units, we saw that the exhaust from the No. 1 unit rose directly to atmosphere while that from the No. 2 unit appeared to be heavier than air and seemed to flow down the outside of the vent line. We climbed to the roof and found that the odor of this heavy exhaust was the same as in the plant. An oily film coated the outside of the vent line.

"The ventilator intake for the plant is located about 50 feet from the vent lines. The fumes were being picked up here and carried throughout the plant.

"We suspected at this point that oil contamination would show up in the condensate and a sample was collected. Analysis of the sample confirmed our suspicion, and investigation by plant personnel showed that a broken weld on the turbine bearing oil return line had admitted from fifty to one hundred gallons of oil to the system."

Cleaning the oil from the system was a big job, but the early solution of the problem prevented real damage.

Waste Water Can Be Costly

Two recent civil suits could have been avoided by proper disposal of waste materials. The outlay for damages and court costs took these plants "off the hook" legally but did not solve their problems.

One plant dumped a water and molasses mixture into a ditch from which it seeped into a well supplying drinking water. The Supreme Court of the state upheld a substantial judgment against the plant, commenting ". . . one who by permitting pollution contaminates the underground water supply of his neighbor's well or spring, commits an act for which he may be required to respond in damages."

Another plant dumped water saturated with a mixture of dirt, chalk and chemicals into a stream. In sustaining an injunction against the continuance of this practice the Supreme Court of this state said, "The principle is that while water is on the land it belongs to the owner of the land, yet he cannot so use and adulterate it as to interfere with the enjoyment thereof by the next owner and if he does so, he is liable in damages for so using it."

Plant-wide Survey Pays Off

The cooling of precious metal bushings presented a critical problem for production and maintenance engineers in a fiber glass plant. Make-up to the open recirculating cooling system was untreated well water; the high "skin" temperatures encountered in the cooling system aggravated the corrosive and scale-forming properties of this water. Plugging of the restricted cooling channels, resulting in overheating of bushings, was a daily occurrence. Aside from production losses, damage to the bushings was often so extensive that recasting was not possible. New bushings cost several thousand dollars apiece.

A plant-wide water survey by Hall engineer W. J. Reese showed the cooling problem to be sufficiently critical to justify split stream softening followed by treatment with a few ppm of glassy phosphate at a controlled pH. Since adopting this recommendation, the plant has operated continuously for two years without one instance of bushing failure resulting from overheating; this service record exceeds the calculated life expectancy of the precious metal bushings by many times. Probably the life expectancy of the Plant Engineer has also been materially improved.

Industrial Water Problems Require Special Handling

There are no "stock answers" to industrial water problems. For information, write, wire or call Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pa.

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STOCKPILES — HD-5G Tracto-Shovel stockpiles coal as it is unloaded from railroad cars at Crown Cork and Seal Co., Baltimore, Md. Also used to load into trucks.

HELPS UNLOAD — Canada Cement Co., Montreal, uses HD-5G Tracto-Shovel with dozer to pull coal and cement from sides and ends of ship hold into reach of crane bucket. Eliminates hand shoveling, speeds up unloading.

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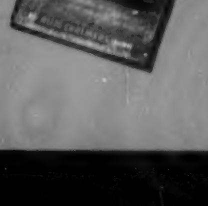

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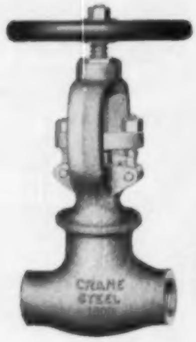

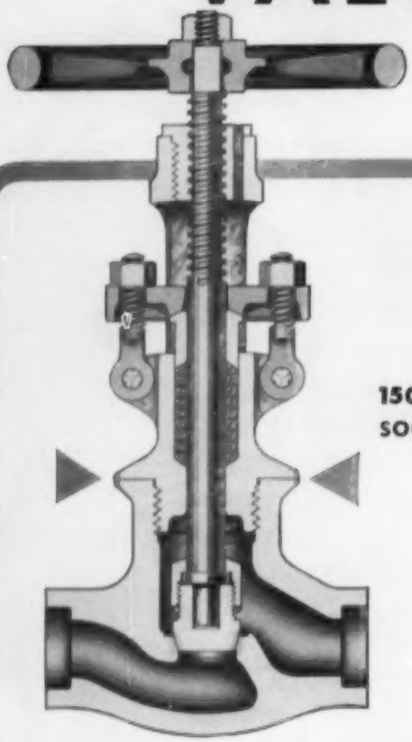

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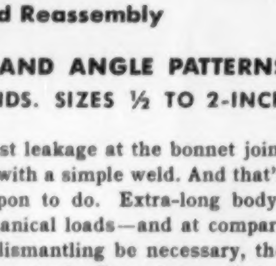

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NALCO Laboratories' continuous research program has gathered this forest of facts about protecting recirculating water systems. In the search for the most effective and economical formula, the metal rods shown have been rotated in all types of recirculating waters and treating chemicals. Results pointed the way to a group of Nalco Treatments which assure users against scale and corrosion in virtually any recirculating waters. For details on Nalco Treatment to fit your particular system, call your Nalco Representative, or write direct.
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● Hardness of makeup water is more than 50 ppm; and sulphates and chlorides, as sodium salts, are less than 150 ppm.
● Calcium hardness of makeup can be as much as 500 ppm.
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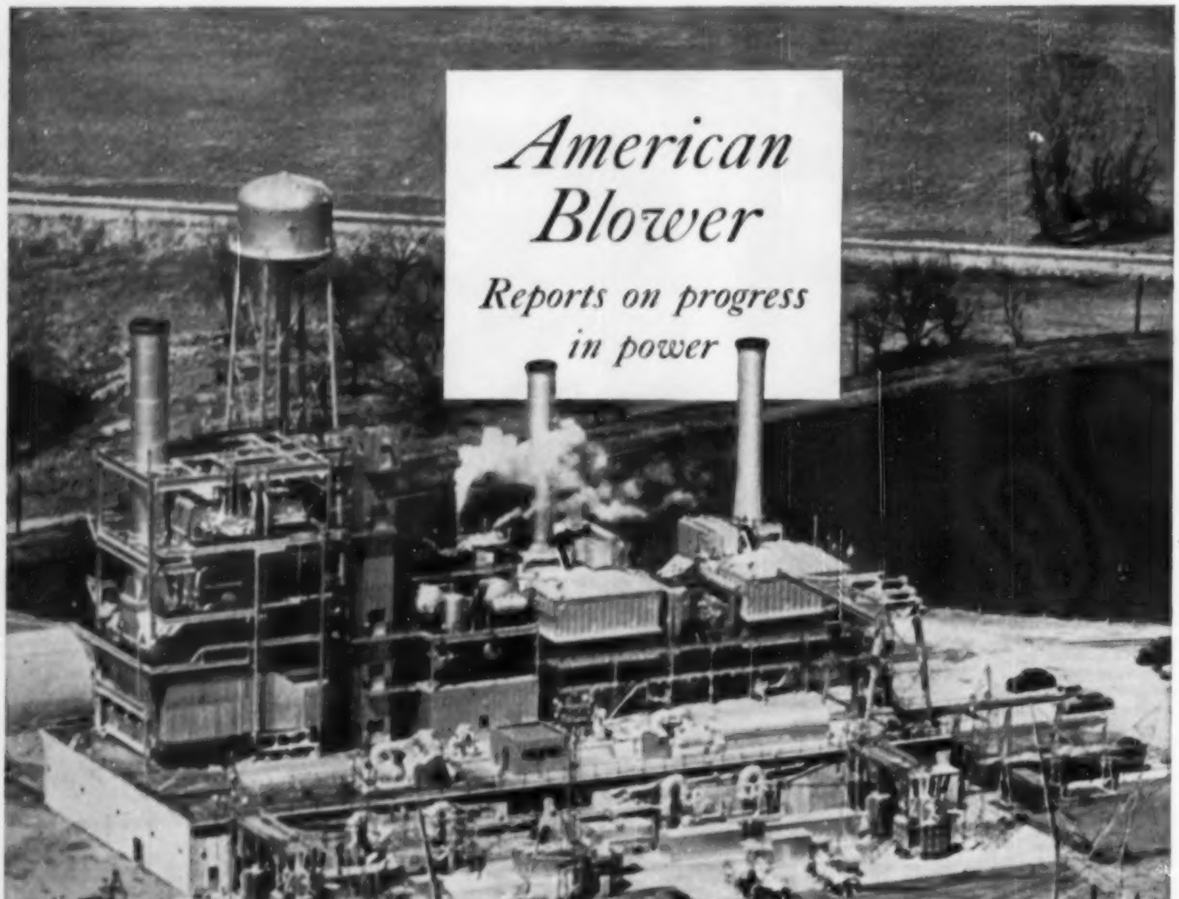

Pictured above is the new Southwestern Station of the Public Service Company of Oklahoma, located on the Washita River, 27 miles west of Chickasha, in the heart of southwestern Oklahoma. This new station assures an abundant supply of dependable electric service for homes, farms, offices and factories.

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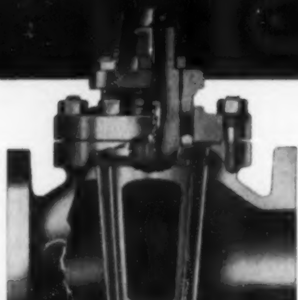

Lubricant system of a Walworth No. 1700F Regular Gland, Wrench Operated, Steel-iron, *Lubricated Plug* Valve. Other Walworth *Lubricated Plug* Valves include Single Gland, and Ball Bearing types. Sizes to 30-inches — pressures to 5,000 psi, and for vacuum service.

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J-M Pump Cups after removal from feed water pumps at Morgan Laundry. Set above consists of 2 J-M "A" Cups with spacer and 2 followers, mounted on pump rod

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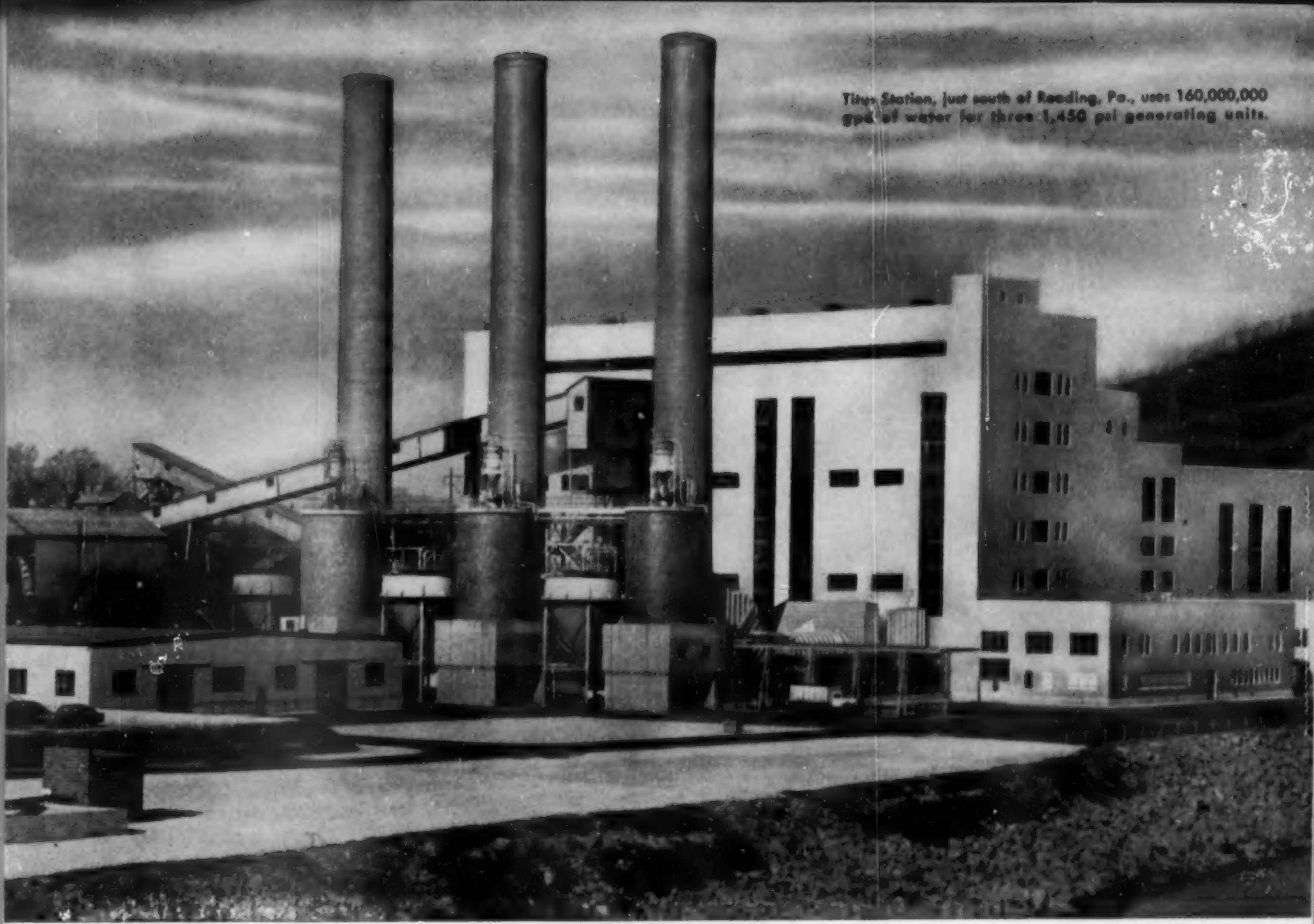

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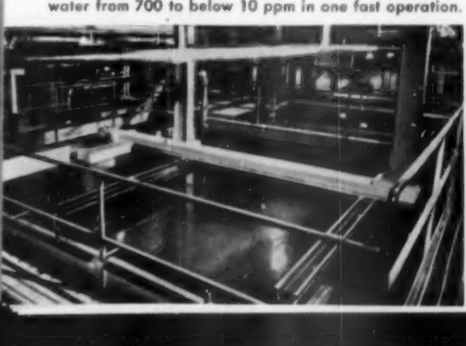

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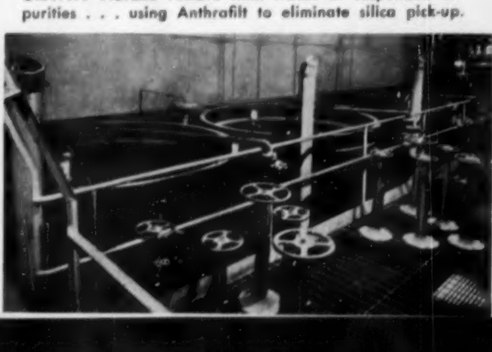

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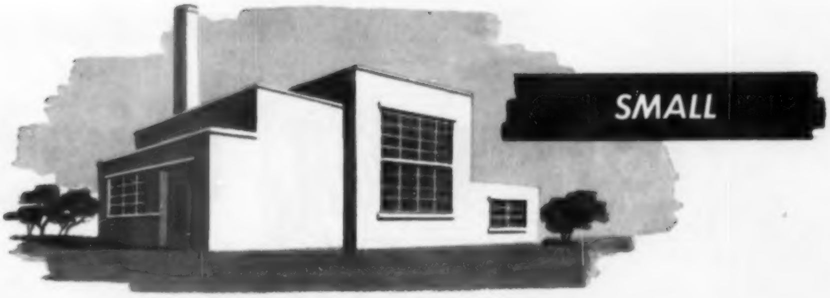

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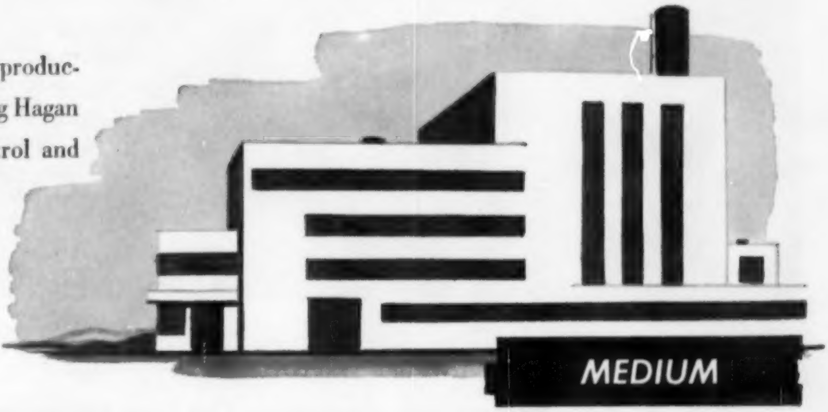

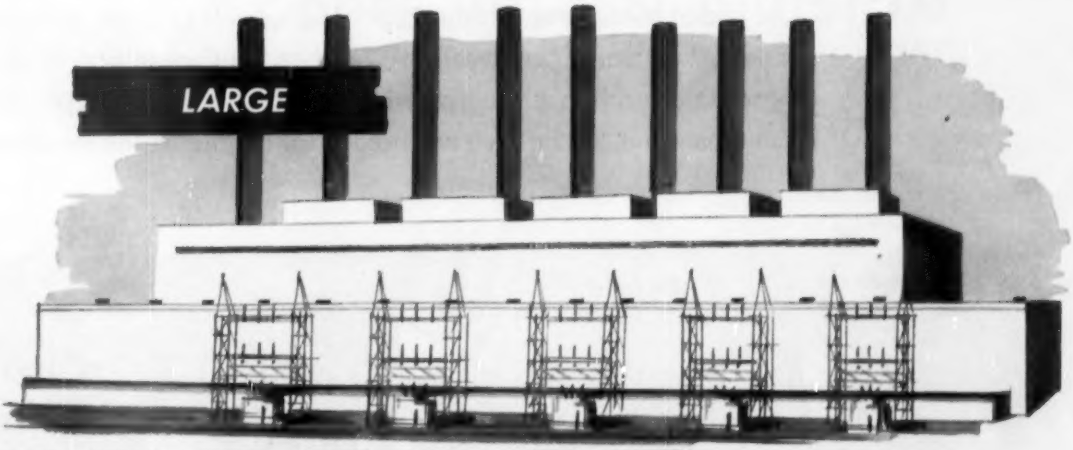

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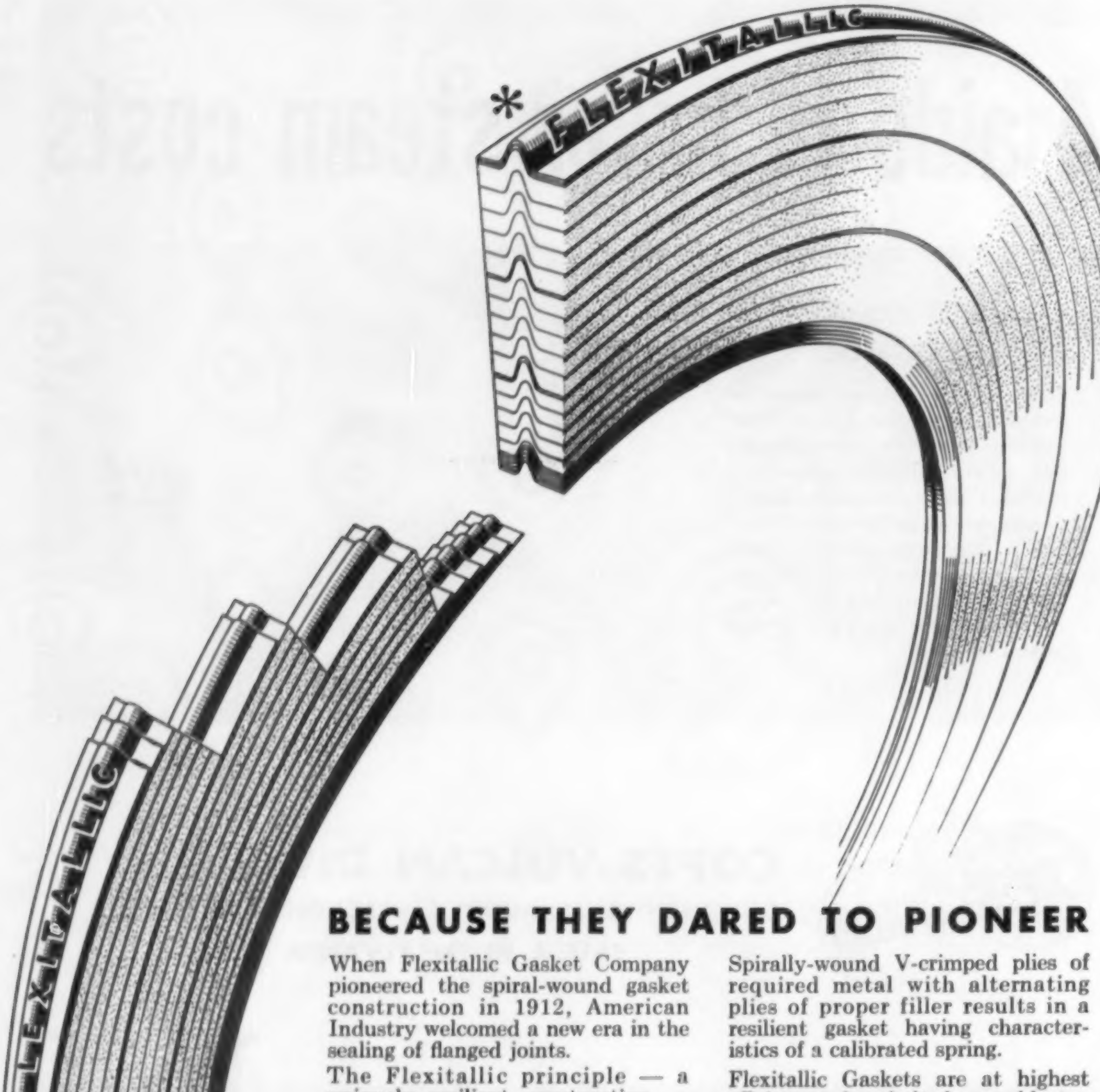

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Editorials

More Legislation for Air Pollution Control

An exploratory conference on intra-state air pollution problems was called by the Joint Legislative Committee on Natural Resources of the State of New York for August 5 in Albany. An invitation of sorts was issued to draw a good cross section of interests, but no public announcement was made. About 100 individuals representing all phases of the air pollution control problem made it their business to attend. One came from as far away as California, others from Ohio and Pennsylvania. And the reason for such a turnout in the middle of the vacation season is obvious. Any legislative program adopted by the State of New York could well set a pattern that much of the nation would follow.

From the welter of opinion and comment one recommendation stood out. It was the statement by Harold Keller, New York State Commissioner of Commerce. We quote: "The Joint Legislative Committee on Intrastate Cooperation, from which the Committee on Natural Resources stemmed, made a major contribution in the field of water pollution. It invited and received the cooperation of industry, which proved conspicuously helpful and constructive. The Water Pollution Control Law and the Board which administers this Law are a direct result of this joint effort. Through this law, New York State has already made great strides in cleaning up the pollution of its lakes and streams. It has done so without any undue hardship on individuals, communities or business. I suggest that the problem of air pollution is a parallel one which might lend itself to similar treatment." Then followed a five-step recommendation, namely:

1. Establish some workable definition of air pollution so a study group can "inventory" chronic conditions and identify source or sources in each instance.
2. Analyze the effects of air pollution not only in public health terms but in damage to real or personal property and hazards to aviation.
3. Study and identify local laws on air pollution as to their applicability on a state-wide basis.
4. Analyze the experience of other states and study their laws and agencies.
5. Correlate these investigations with others under way on inter-state problems since any New York metropolitan area air pollution survey must recognize this aspect.

The above five-step recommendation embodies a sober, well-studied approach to a problem whose eventual solution will unquestionably be a series of compromises. How fair or how lasting these compromises will be depends on how well grounded the studies are that prompted them.

We earnestly hope the New York legislators will ponder long over this problem and not act hastily. In the words of Mr. Keller "...I urge the constructive help of industry be solicited so that the end result will be a stimulant rather than a deterrent to the economy of our State." These are praiseworthy sentiments and we feel an excellent guide not only in framing any future air pollution control laws but in administering them as well.

Why Limit Engineering to Engineers?

In the last decade engineering curricula in many colleges and universities have been broadened to include more studies in the fields of liberal arts. Many advantages result from this arrangment. The engineering student is required to think along lines other than his specialized technical interests. He has the opportunity to gain an appreciation of art and literature, to become acquainted with the great leaders in political science and philosophy and to gain at least an introduction to the rapidly developing social sciences. All of this should be an aid to making the engineer of the future a better educated citizen.

But many engineering students, especially those attending institutions having a number of professional schools, are prompted to ask whether a knowledge of technology would likewise be an asset to non-engineers. Why not acquaint future lawyers, teachers and merchants with engineering—its methods and its impact upon contemporary life?

At least one university has recognized this need. Last May Professor Jerry S. Dobrovolny presented a paper before the Illinois Academy of Sciences in which he described a pioneering course in the philosophy and methods of engineering which was offered to non-engineers at the University of Illinois on two occasions last year. Here are some of the topics that were discussed in the course: typical problems solved by engineers and methods used in their solution; a historical account of the development of engineering; and responsibilities of the engineering profession in social, economic and technical matters.

Although only in its first year, this course has already proved of measurable utility to students in three fields: future teachers who will have to counsel secondary-school students interested in engineering, students planning to enter government service, and law students who plan to specialize in patent or corporation law. It also has potential liberalizing value for other non-engineering students who wish to learn how technology has come to assume its present importance and influence.

Engineering methods are of potential use to many who are outside the profession. It is to be hoped that this pioneering course at the University of Illinois will induce other engineering schools to introduce similar studies so that engineers and their methods will find wider understanding by students in many fields.

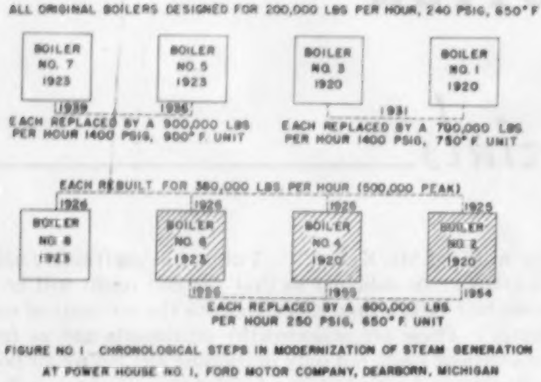


Fig. 1—Above block chart shows how the major elements of the boiler room have been periodically improved to meet the plant steam needs efficiently

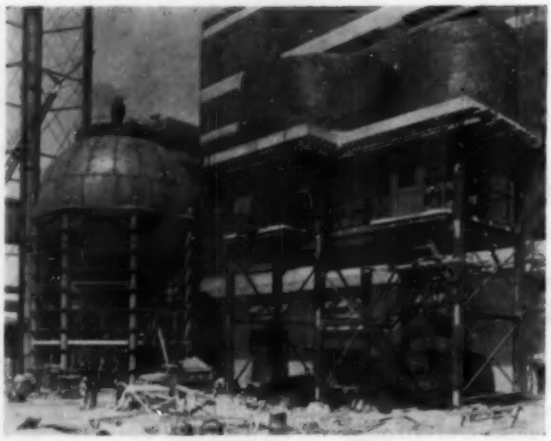


Fig. 2—In addition to the boiler improvements water-treatment aids like sedimentation tank, left; ash handling equipment and silos, right, are going into service as needed

Rouge Plant Modernizes Its Steam Generation

The Rouge Plant of the Ford Motor Co., Dearborn, Mich., has consistently kept abreast of fuel-burning and steam generation progress since its construction in 1920. Here is the latest in a series of modernization steps, all within the original floor space, that will see the original equipment quadrupled in capacity with all but one of the original boilers replaced.

By L. F. O'REILLY

Project Engineer, Ford Motor Company

and W. J. FADDEN, JR.

Project Engineer, The Kuljian Corporation

STEAM generation is again undergoing modernization at the world-famous Rouge Power Plant. The present program includes: (*a*) replacement of low pressure units No. 2, No. 4, and No. 6, with 600,000 lb per hr steam generating units operating at 250 psig, 650 F; (*b*) installation of dust collectors and fly ash and bottom ash-handling equipment for all eight units, including 600-ton fly ash and 150-ton bottom ash storage silos; (*c*) installation of a 200,000 gallons per hour hot lime process softener system, including filters, hot zeolite softeners, 1,500,000 lb per hr thoroughfare type deaerating heater, and low pressure boiler feed pumps. The engineering and construction is being done by The Kuljian Corporation, engineers and constructors, Philadelphia, Pa., under the supervision of J. A. MacAlarney, Director, Plant Engineering Office, Manufacturing Staff of Ford Motor Company, Dearborn, Michigan.

History

The Rouge Power Plant, also known as Power House No. 1, has always had greater steam capacity than any other industrial power plant. Fig. 1 portrays the chronological steps in modernization of its steam generating equipment. Within thirty-five years, the most modern industrial power plant of its time will have replaced all except one of its original boilers nearly quadrupling its original capacity; and all this accomplished within the same floor space occupied by the eight original units.

The original low pressure units, installed in 1920, were the largest ever built up to that time and were the first large units designed to use pulverized coal as the primary fuel. Although the original furnaces had solid walls, capacities of 200,000 pounds of steam per hour could be maintained.

By 1925 Ford production had increased considerably. There was a tendency toward greater concentration of production at the Rouge Plant, so much so that raw materials were completely converted into the finished product, which moved under its own power from the end of the assembly line. With this increase in production power requirements climbed and the low pressure boilers originally used for electric generation were in need of help to increase their capacity. The coal-burning capacity was doubled by doubling the number of burners. Next, lining the inside of the furnace with steam generating and steam superheating surface produced essentially a radiant heat boiler entirely independent of the original convection boiler. The remodeled units (four of the original units) were designed for 380,000 lb per hr of steam but in practice, an actual peak evaporation of over 500,000 lb per hr was attained. The efficiency of the re-

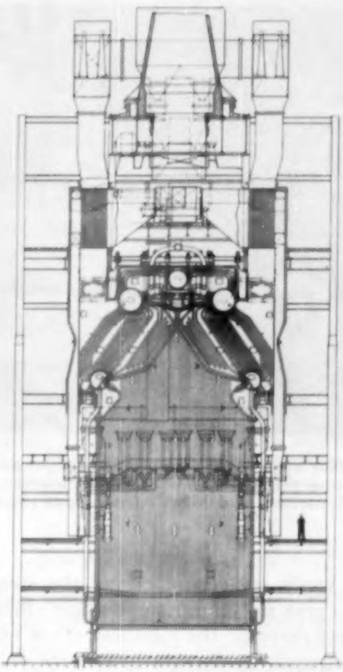


Fig. 3—Cross-sectional view of the first twin boiler installation, a 600,000 lb per hr, 250 psig, 650 F design, now going in on the current modernization program

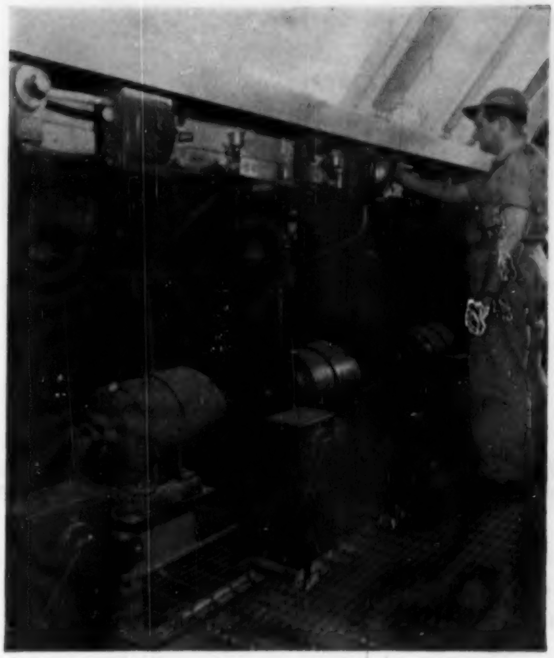


Fig. 4—New boilers employ twelve coal feeders to the tangential burners, six to each side. Here is a close-up view of some of the coal feeders and drives. The feeders are located below the pulverized coal bunkers

modeled unit, as compared with the original unit, was raised from 80 per cent to approximately 84 per cent at rated load. The new low pressure units (1954–1955–1956 replacements) are to have an efficiency of 86.5 per cent.

By 1929, Ford production was again taxing the capacity of the power plant. But progress by this time permitted a better solution than further remodeling of the remaining four original units. Two of the original units were replaced with high pressure units which, when completed in 1931, were the largest in the world. The two remaining completely original units were replaced in 1936 and 1939, respectively, with again the largest capacity high pressure units in the world.

The steam generated by the high pressure units now supplies electric generation needs solely. The steam generated by the low pressure units handles the balance of the plant needs such as driving the turbo-blowers, process purposes, various plant uses, and building heating. An increasing demand for low pressure steam and the age of the existing low pressure units, however, has led to the present replacement of three of these units. It is contemplated that the remaining low pressure unit will be replaced with a high pressure unit soon.

Steam Generating Unit No. 2

Steam generating unit No. 2 has just been completed and is, at the time of this writing, ready for operation. The steam generator consists of two Combustion Engineering, Inc., two-drum bent tube boilers (so called twin boiler) installed over a common water cooled furnace. Each boiler feeds into a common dry drum which is connected to separate superheaters, one for each boiler, Fig. 3. The superheaters connect in turn, to individual superheater outlet headers, then to a common desuperheater header. The unit is designed to operate at 250 psig pressure and 650 F at the superheater outlet.

A bank of burners in each corner fire tangentially into the furnace, Figs. 4 and 5. These units can burn pulverized coal, blast furnace gas, coke oven gas, and oil (future) individually or in any combination at one time. For combustion control purposes, only the combination of blast furnace gas and pulverized coal is considered. Bunker "C" fuel oil for future firing will be under automatic combustion control. Coke oven gas, planned primarily for pilot flame only, is used for warming up purposes, however, and on week-ends to enrich the b. f. gas.

Blast furnace gas pressure is normally regulated so that all other users in the plant get preference and the boiler house uses the surplus. Each boiler unit derives its supply from two 36-in. gas mains; each main, equipped with its own flow measuring orifice, serves a pair of corners. A totalizing type meter records the blast furnace gas flow to the unit. The maximum capacity of the unit when firing blast furnace gas is 500,000 lb per hr of steam. Pulverized coal from the existing bin system is fed to the burners by twelve feeders, each driven by a 250-v variable speed, direct current motor. Two primary air fans are provided, each using preheated air, and each equipped with inlet control damper and outlet shut-off damper. Primary air feeds into each pulverized coal fuel line immediately below each feeder. The capacity of the unit when firing pulverized coal is 600,000 lb per hr.

The steam generating unit has two double inlet type forced draft fans with inlet vanes for control purposes and remote manually operated outlet dampers for low loads. Heated air is partially recirculated to the forced draft fan inlets under the local regulation of manually operated dampers. The forced draft fans employ con-

Fig. 5—Excellent construction view shows two of the four tangential burner assemblies with coal feed at top and blast furnace gas supply through side boxes

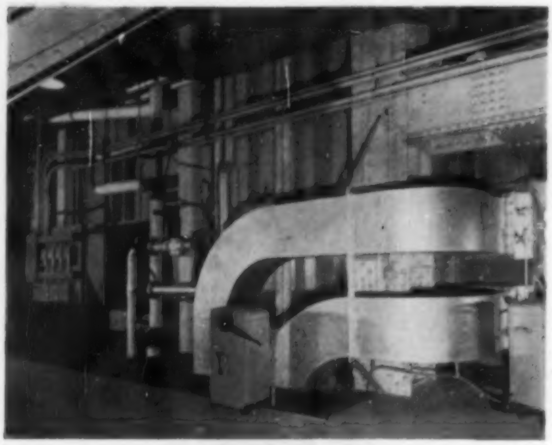


Fig. 6—Exterior view of completed blast furnace gas ductwork shows operating floor push button station, coke oven gas control, center, and blast furnace gas control, right

stant speed motors for drives and discharge into a common plenum chamber.

Two induced draft fans are provided and constant speed motors drive them. Control is effected by inlet louver dampers. The fans discharge into the base of the existing 168 ft high, steel stack supported on the roof of the plant. Each steam generating unit in the plant is provided with an individual stack.

Steam generating unit No. 2 carries two economizers, two tubular type air preheaters, and two mechanical Aerodyne type dust collectors. One collection system is provided for the east halves of both dust collectors (another for west halves), including cyclones, soot hopper and secondary air fan. Each secondary air fan discharges into the inlet of one dust collector. Each dust collector is provided with motor operated rappers and remote manually operated by-pass dampers. The dust collectors meet the requirements of the City of Dearborn, Michigan, and are guaranteed as having a fly ash emission of not more than 0.2 gr per cu ft reduced to the design stack temperature when firing 100 per cent pulverized coal. The efficiency is expected to be 92 per cent with a pressure drop through the collector of 1.6 in. of water.

The steam generating unit can operate at reduced capacity with one forced draft fan, one primary air fan, one induced draft fan, and one dust collector secondary air fan. However, both economizers, both air preheaters, and one half of each dust collector must be used.

Soot collected in the rear pass hoppers is reinserted into the corners of the furnace with the use of soot exhausters operated by compressed air.

Combustion Control System

Pulverized coal firing. The automatic combustion control system provides complete regulation of pulverized coal supply, forced draft, primary air, and induced draft on the unit. The fuel supply and forced draft are controlled through the master controller in accordance with the steam demand as indicated by changes in the steam pressure.

The forced draft control depends upon regulating the inlet vanes on the forced draft fans with remote manual secondary adjustment of the outlet dampers. The control of the vanes is determined by the steam flow-air flow ratio to give maximum combustion efficiency.

The control drive on the inlet louvers of each induced draft fan responds to changes in furnace draft so as to maintain a predetermined draft at a designated point in the furnace.

Controlling the speed of the individual d-c motor operated coal feeders regulates the coal supply. Each motor has its own field rheostat capable of individual adjustment; however, these rheostats mount in a way that they all can be operated by one control drive. The starting controls for the feeders are so arranged that groups of two feeders can fire opposite corners of a pulverized coal elevation at the same time. A solenoid air valve operating on 250-v d-c for each coal feeder assures that in the event of current failure the air supply to the individual air cylinder operated primary air valve would cut off and the primary air to the particular burner stops.

The primary air fans have their inlet dampers controlled from the duct pressure to maintain a predetermined pressure regardless of the number of burners.

Blast furnace gas firing. Provision is made for the complete regulation of blast furnace gas supply, forced draft and induced draft, in addition to steam pressure. The methods of controlling steam pressure, forced draft and induced draft follow the same scheme and are applied on the same drives as for pulverized coal.

Blast furnace gas is controlled by adjusting the flow of gas through eight 24-in. butterfly valves, each feeding a burner, Fig. 6. A shut-off damper adjacent to each burner to prevent flash backs is remote manually operated. Since the blast furnace gas pressure to the plant varies, two 36-in. butterfly valves, one in each branch feeding the unit, regulate and maintain a constant pressure prior to the control valves.

Coke oven gas firing. The air register for the coke oven gas burners requires manual adjustment for proper combustion based on an Orsat reading. This air setting must be changed if the set amount of coke oven gas is decreased or increased. One automatic pressure control valve is provided for each bank of coke oven gas burners.

The air operated combustion control system is capable of being partially or completely operated manually.

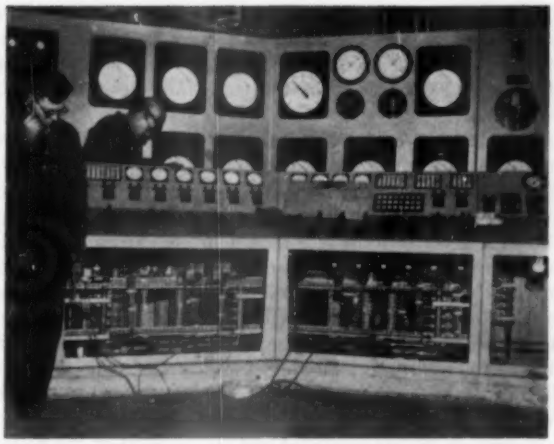


Fig. 7—Units No. 2 and No. 4 will have a common control room. First, or Unit No. 2 board, appears above as it looked during construction phase

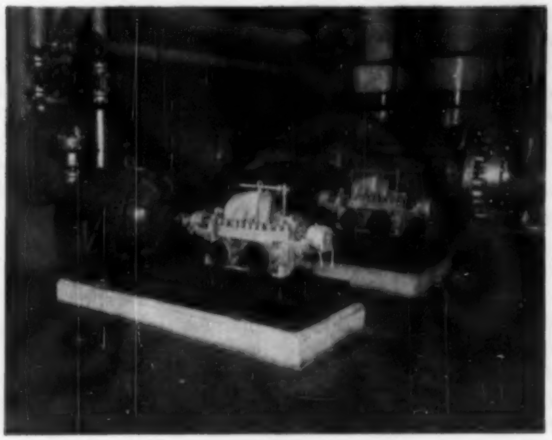


Fig. 8—Boiler feed pumps, shown in the background, are for the existing high pressure boilers. New desuperheater pumps appear in foreground

Steam Temperature Control

For pulverized coal firing the operator sets the tilting angle of the burners to produce as closely as possible the required temperature at the superheater outlet. The two-element system then refines the adjustment of this temperature to accomplish the required exit temperature. For other fuels the two-element system completely controls the temperature of the steam leaving the superheaters. The desuperheating unit is a steam-assisted spray type. Measuring elements used to control the exit temperature are the steam flow and steam temperature in the boiler lead.

Two desuperheater pumps, Fig. 8, furnish turbine condensate through a diaphragm motor operated control valve to the desuperheater on each of the three new low pressure units. When the demand for condensate falls off the condensate automatically recirculates from the desuperheater pump discharge header. Each desuperheater pump has a capacity of 225 gpm at 375 psig discharge pressure.

It will be possible in the future, by the addition of a small amount of equipment, to control the temperature of the steam by tilting the pulverized coal burners automatically.

Electrical Interlocking System

The forced draft, induced draft, primary air and fuel supply interlock so that the following operation results:

a.—Failure of both induced draft fans stops both forced draft fans and leaves all dampers and vanes wide open. Failure of one induced draft fan results in the closing of its inlet louver and the stopping of its paired forced draft fan and the closing of its inlet vanes. The remaining pair of fans then automatically adjust so that they can carry their maximum percentage of the steam generator rating, and the fuel feeding rate automatically reduces to match this percentage.

b.—For pulverized coal firing, failure of any one of the 12 coal feeder motors automatically interrupts the power supply to a group of two feeders in which the defective feeder belongs. Failure of one of the primary air fans results in the closing of its outlet louver damper and shuts down two groups of coal feeders. Failure of both primary air fans and all coal feeders shut down. The automatic combustion control equipment, in case of one fan failing, automatically makes adjustments for the reduced firing rate to maintain safe and efficient combustion.

c.—For blast furnace gas firing, failure of the fuel supply produces a tight closing of all gas flow control valves and the closing of an annunciator circuit. Low pressure alarm switches are provided and may be set at a predetermined low pressure.

d.—Failure of coke oven gas, as indicated by predetermined pressure in the burner supply lines, automatically shuts off the fuel and closes an annunciator circuit.

e.—For all fuels, failure of both forced draft fans results in the shutting down of all fuel feeds, only one induced draft fan, and both primary air fans if they are operating. Failure of one forced draft fan causes its inlet vanes to close and its paired induced draft fan to shut down and close its inlet louver damper.

f.—The starting procedure follows: Either one or both of the induced draft fans must be running to permit the starting of their paired forced draft fans. After which time, for pulverized coal firing, the primary air fans are started and subsequently after a 15-second time delay the coal feeders are started up in groups of two. When burning blast furnace gas, the fuel control valves are opened after the forced and induced draft fans are operating.

g.—Primary air butterfly valves are paired with coal feeders so that the butterfly valve can open only when the paired feeder is running, and the valve will remain open for 15 seconds after the coal feeder is shut down.

Control Room

Unit No. 2 and Unit No. 4 have a common control room, Fig. 7, as will Unit No. 6 and Unit No. 8. The boiler instruments, remote control switches and combustion controls are located on a vertical and a desk type panel. The control room, Fig. 7, is enclosed and is pro-

vided with filtered air—future air conditioned. Lighting is fluorescent behind eggcrate ceiling.

The control room also contains an intercommunication system which enables the control room operator to speak with operators at various elevations and positions surrounding units No. 2 and No. 4.

The majority of control lines to and from the control room are carried in Armortube, groups of 6, 8 and 12 lines within a protective, flexible steel covering.

Water Level Control

Unit No. 2 has two separate feeds, each with a control valve operated by a three-element control system. Both feeds come off a 12-in. loop header system which serves all of the low pressure units. The boiler feed water control elements are boiler drum level (two elements), steam flow from boiler (common to both), and feed water flow to boiler (two elements). Water input is maintained in proportion to steam output and holds the level within plus or minus $^3/_4$ inches of desired normal level.

Chemical Feed

One duplex chemical feed pump feeds sodium metaphosphate or sodium nitrate directly to the boiler drums. The pump handles 0–20.8 gph at a discharge pressure of 500 psig and is driven by a totally enclosed constant speed motor. The pump measuring cylinders, displacement plungers, and so forth, are constructed of stainless steel. A 125-gal chemical solution tank now has a dual propeller agitator for mixing chemicals and employs an automatic intermittent feed control system with adjustable feeding and flushing periods. A copper cooling coil permits cooling the deaerated water used in flushing. Eventually, each steam generating unit will have its own chemical feed pump and a common pump suction will be taken from two chemical solution tanks.

Bearing Cooling

Two bearing cooling water pumps supply cooling water to the fan bearings, ash conveyors and sample coolers for the complete plant. These pumps have a capacity of 500 gpm at 300 ft discharge pressure and act as emergency fire pumps.

Ash Hopper and Screw Conveyor

Steam generating unit No. 2 has a unique refractory lined ash hopper. In it a water cooled screw conveyor, protected from direct furnace radiation by a refractory shield, carries ash from the ash hopper to a crusher immediately adjacent. The ash crusher then discharges the ash into a pneumatic conveying system. It was decided to use this type of ash hopper and screw conveyor because the existing units are of the same type, and have proved very satisfactory with very low maintenance costs. Parts are interchangeable on all units; therefore, a minimum amount of spare parts need be kept on hand.

Nitrogen Purging System

Inasmuch as nitrogen is a by-product at the Rouge Plant, it was decided to use this medium for purging the blast furnace gas lines in the boiler house. Purging of these lines is not only necessary for maintenance purposes, but occasionally a flash-back occurs in one of the blast furnace gas headers and must be snuffed out before any great damage occurs. For this reason, a push button panel located near the main exit from the boiler house makes it possible to operate from this one point any of the solenoid valves required to purge any desired branch or header.

Five bottles, each containing 300 cu ft of nitrogen at high pressure, are racked and manifolded into a header. From this header the pressure is reduced to 15 psig in two stages. A three-way solenoid valve feeds nitrogen through a water loop seal into a branch from the main blast furnace gas. Each branch (two per steam generating unit) has its individual rack of nitrogen bottles, pressure reducing station, solenoid valve and water seal. In addition, the 15 psig nitrogen headers tie together and feed a solenoid valve on each blast furnace gas main as they enter the boiler house. For maintenance in the furnace or in the gas headers from the mains, special blanking plates are provided and are inserted on the boiler side of the 36-in. butterfly control valves adjacent to each main. Then, these lines are purged with nitrogen before maintenance is begun. Water entering the loop seals discharges through the three-way solenoid valves to the drain. When a solenoid valve is energized, its corresponding loop seal is blown out by the nitrogen. After a solenoid is energized it must be reset manually. In the case of lack of nitrogen, water or steam can be used for manually purging the blast furnace gas mains.

In addition to purging of blast furnace gas lines, provision is made to purge the coke oven gas mains.

Structural Problems

Installing a 600,000 lb per hr steam generating unit, along with dust collectors, in the place originally occupied by a 200,000 lb per hr unit, presented numerous structural problems. Loading of the existing building columns had to be kept within safe design limits and still keep foundation loading below the maximum allowable. The existing foundation, fortunately, was a continuous mat having an approximate thickness of 9 ft, supported on ample piling. Equipment selection not only involved cost as a major item but also overall weight.

To keep loading to a minimum it was decided to enclose the induced draft fans with corrugated siding rather than extend the masonry building walls. This enclosure is equipped with adjustable louvres for ventilation purposes.

It was necessary to revise the existing pulverized coal bunkers to maintain proper equipment clearances. It also was necessary to provide small compartments in the sides of the bunkers so that the retractable soot blowers can be properly operated.

A dividing plate was added to separate the pulverized coal for unit No. 1 from that for unit No. 2. Chutes were added so that pulverized coal can be fed from either existing screw conveyor above the bunkers to either side of the divided bunker. The gunite lining was replaced on the revised coal bunkers.

It was necessary to add wind bracing between the building columns, which are also used as boiler columns. It was also necessary to replace the main bunker girders. All structural changes and additions were accomplished while the adjacent units remained in operation.

Any modernization program that requires revamping or replacement without a break in production puts a heavy stress on ingenuity and resourcefulness.

Electrical

The forced draft, induced draft, and primary air fan drives are all 2300-v, 3 phase, 60 cycle, squirrel cage, constant speed motors having class B insulation. These units have across-the-line starters in the new 2300-v metal enclosed switchgear having removable type air circuit breakers.

The coal feeders have 250-v d-c adjustable speed motors, controlled from a new 250-v d-c circuit breaker and starter compartment.

All other drives are 440-v, 3 phase, 60 cycle motors, controlled from centralized motor control centers.

The equipment table below indicates more of the details of operating requirements for individual larger electrical motors such as constant speed, variable or adjustable speed throughout the boiler plant.

Conclusion

The replacement of the low pressure steam generating units (described above), along with the addition of dust collectors to all units, the new ash handling system, and the new water treatment system for the low pressure units are all included in the present expansion program to modernize the power plant. This expansion, when finished, will complete another chapter in the epic story of the Rouge Power Plant, which until recently was the largest industrial power plant in the world and is certainly the most famous.

Editor's Note: A most comprehensive set of controls was furnished on the vertical and desk type panels shown in Fig. 7. The exact nature and a full listing of the individual instruments were given but for space reasons they are not presented here.

PRINCIPAL EQUIPMENT LIST

MODERNIZATION OF POWER HOUSE NO. 1, ROUGE PLANT, FORD MOTOR COMPANY, DEARBORN, MICHIGAN

STEAM GENERATING UNITS

Steam Generating Units, 3, (1954, 55, 56) ..... Combustion Engineering, Inc.
Twin Boiler, 46,500 sq ft heating surface; water walls, 19,220 sq ft heating surface; furnace volume, 40,400 cu ft; 320 psig, design pressure; arranged for pulverized coal, blast furnace gas, coke oven gas, and oil, tangential firing; two 60-in. dia upper steam drums, two 48-in. dia lower mud drums, one 48-in. dia dry drum.

Superheater, 2 per unit ..... Combustion Engineering, Inc.
Elesco rolled joint pendant-type, designed to raise temperature of steam to 650 F.

Desuperheater, 1 per unit ..... Combustion Engineering, Inc.
Steam-assisted spray type, designed to limit steam temperature to 650 F.

Economizer, 2 per unit ..... Combustion Engineering, Inc.
Elesco continuous loop, finned horizontal tube type, 4500 sq ft heating surface each.

Air Preheater, 2 per unit ..... Combustion Engineering, Inc.
One pass air, tubular type, 25,100 sq ft heating surface each.

Coal Feeders, 12 per unit ..... Combustion Engineering, Inc.
Type R duplex, at outlet of pulverized coal bunkers; 2 and 3/4 hp, 2000/500 rpm, 250-v d-c, adjustable speed motor.

Primary Air Fan, 2 per unit ..... American Blower Corporation
27,000 cfm each, 345 F, 10-in. wg., size 6, single inlet 1/3 single width, Sirroco, 1200 rpm; 100 hp, 2300-v, 3 phase, 60 cycle, constant speed, squirrel cage motor.

Burners ..... Combustion Engineering, Inc.
12 tilting type, pulverized coal burners; 8 blast furnace gas burners; 16 coke oven gas burners; 8 oil burners; all tangentially arranged, per unit, in four corners; complete with hand-operated air-regulators.

Forced Draft Fan, 2 per unit ..... American Blower Corporation
96,000 cfm each, 9.1-in. wg., 100 F, #486, double inlet, double width, inlet vane control, 1175 rpm; 200 hp, 2300-v, 3 phase, 60 cycles, constant speed squirrel cage motor.

Induced Draft Fan, 2 per unit ..... American Blower Corporation
258,000 cfm each, 10.0-in. wg., 475 F, #735, double inlet, 1/3 double width, Sirocco, inlet louvre control, 585 rpm; 700 hp, 2300-v, 3 phase, 60 cycle, constant speed, squirrel cage motor.

Soot Blowers, per unit ..... Diamond Power Specialty Corporation
Air-operated, sequential from control room, steam blowing; 6 IK retractable, 8–2-in. G9B Dialoy units, 8–2-in. G9B calorized units, for boiler and superheater; 8–2-in. G8B steel units for economizer; 20 short retracting units for furnace walls.

Ductwork and Steel Casing ..... Combustion Engineering, Inc.
Ash Hopper and Screw Conveyor ..... Combustion Engineering, Inc.
Setting and Insulation (with erection) ..... Combustion Engineering, Inc.
Electrical Switchgear ..... General Electric Company
Motor Starters, 12 ..... Electric Controller & Mfg. Co.
Motor Control Centers, 5 ..... Clark Controller Company
D-c Circuit Breaker and Control Panels ..... Westinghouse Electric Company
Auxiliary Relay Panel, 1 ..... Allen-Bradley Company
Desuperheater Pump Recirculating System ..... Bailey Meter Company
Smoke Density Recorder, 1 per unit ..... Bailey Meter Company
Temperature Recorders ..... Bailey Meter Company
Oxygen Recorder, 1 per unit ..... Bailey Meter Company
Draft Gages ..... Bailey Meter Company
Steam Pressure and Temperature Recorder ..... Bailey Meter Company
Flow Meters ..... Bailey Meter Company
Feed Water Regulator and Control ..... Bailey Meter Company
Combustion Control ..... Bailey Meter Company
Boiler Instrument Panels ..... Bailey Meter Company

Desuperheater Feed Pump, 2 ..... Byron Jackson
225 gpm, 375 psig discharge pressure, centrifugal, 4 stages, flooded suction, 180 F condensate; 100 hp, 220/440-v, 60 cycle, totally enclosed fan cooled motor.

Chemical Feed Pumps and Tank, 6 and 2 ..... Milton Roy Company
Duplex, each cylinder 20.8 gph maximum, sodium metaphosphate and sodium nitrate solution, 525 psig, 70 F, screw adjusted stroke length, stainless steel construction; 1/4 hp, gearhead motor, totally enclosed, 3 phase 60 cycle, 220-v/440-v; stainless steel relief valve, strainer; 125 gallon steel tank with agitator; Hagan type E automatic intermittent feed control system; Hagan copper cooling coil, type B.

Cooling Water Pumps 2 (existing) ..... Union Pump Company
500 gpm at 200 F, 8 ft NPSH; 3 stage, centrifugal, horizontally split, 300 ft discharge head; 60 hp, 220-v/440-v, 1755 rpm, Reliance motor.

*Fabricated Piping ..... Blaw-Knox Construction Co.; W. K. Mitchell & Company
*Piping Erection ..... The Kuljian Corp.
*Hangers, Anchors and Supports ..... Grinnell Company, Inc.
*Expansion Joints ..... Moisson Packing & Rubber Co.; American District Steam, Inc.
*Valves ..... Schutte and Koerting Co.; Crane Company; Chapman Valve Mfg. Co.; Henry Pratt Co.; Sheffler-Gross Co.; Henry Vogt Co.; Ohio Injector Co.; Beaumont Birch Co.; Ruggles-Klingeman Mfg. Co.; Edwards Valves, Inc.; Coon-De Visser Co.; Automatic Switch Co.; Leatherman and Co.
*Pipe, Fittings, etc. ..... United Conveyor Corp.; The Parker Appliance Co.; Bailey Meter Company; Elliott Co., Inc.; Smith-Matthews Fdry. Co.; Chas. F. Guyon, Inc.; Goon-DeVisser Co.; Crane Company; I. Burack, Inc.; Harry W. Taylor Co.; Revere Copper & Brass Co.; W. T. Andrew Co.; Taylor Supply Co.
*Pressure Switches ..... R. L. Deppmann Co.; Mercoid Corporation
*Gas Welding ..... Combustion Engineering, Inc.
*Welding Inspection (Boiler) ..... Hartford Steam Boiler & Ins. Co.
*Radiographic Examination (Pipe Welds) ..... Industrial X-Ray Inc.
*Erection of Steam Generating Unit ..... The Kuljian Corporation
*Demolition and Removal Existing Unit ..... Cuyahoga Wrecking Co.
*Rigging Boiler Parts ..... Darin and Armstrong, Inc.
*Fresh Air Ducts (Sheet Metal Work) ..... Van-Truer Co., Inc.
*Roofing and Sheet Metal Work ..... Schreiber Roofing Co.
*Miscellaneous Iron Work ..... Allied Steel and Conveyors, Inc.
*Guniting Coal Bunkers ..... Hanna, Zabriskie & Daron, Inc.
Electrical Installation ..... Harlan Electric Co.
*Piping Insulation ..... Armstrong Cork Co.
*Corrugated Siding and Louvres ..... W. Biddle Walker Co.
Filtered Air System (Control Room) ..... Spitzley-Retemier Sheet Metal Co.
Metal and Glass Partitions (Control Room) ..... E. F. Hauserman Co.
*Structural Steel (Fabrication) ..... Max Corchin & Sons; Combustion Engineering, Inc.
*Bunker Steel (Fabrication) ..... Max Corchin & Sons
*Structural Steel and Bunker Steel (Erection) ..... The Kuljian Corporation
Aluminum Ceiling Panels (Control Room) ..... E. H. Cantile Sales Co.
*Paint ..... Durako Paint & Color Co.; E. I. du Pont de Nemour, Inc.; Alchrome Paint Products
Engineers and Constructors ..... The Kuljian Corporation

* Refers to Unit No. 2 only—suppliers or contractors.

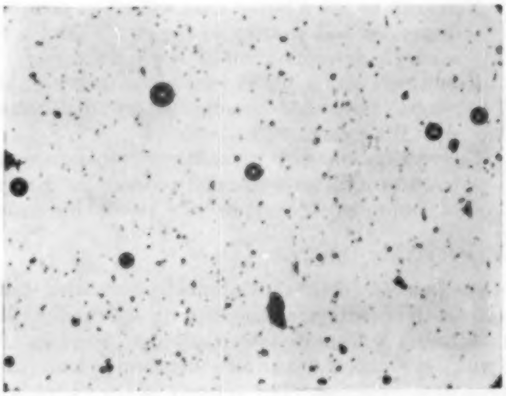


Fig. 1— Photomicrograph of sample of pulverized coal fly ash chosen as standard

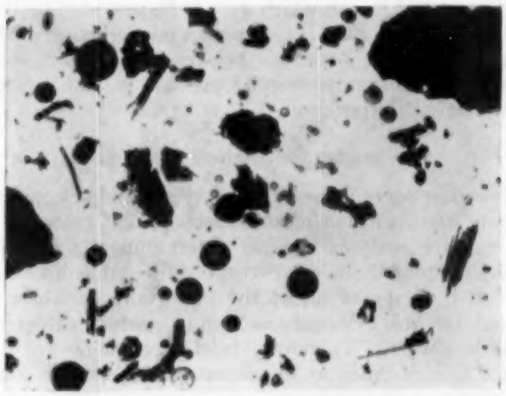


Fig. 2—Photomicrograph of fly ash from spreader-stoker-fired boiler furnace

A Comparison of Size-Consist Determinations of Duplicate Samples of Fly Ash

By W. C. HOLTON AND DANA F. REYNOLDS, JR.

Battelle Memorial Institute

Size-consist determinations were made by four independent laboratories on a total of eight duplicate samples of fly ash and the results were compared. This comparison showed that the maximum deviation from the average of the percentage undersize for the two samples analyzed by each laboratory was usually less than 10 percentage points. The terminal velocities calculated from the data reported showed a difference of about 25 percentage points between the limits in the amounts of material settled at any given terminal velocity. The variation in particle sizes was of the same order. It would be expected that the correlation of results obtained in a single laboratory, or those found by different laboratories analyzing duplicate samples, would be better than was reported. The lack of agreement indicates both the difficulty of the analytical methods and the need for better instrumentation in this field.

THE accurate determination of the size consist of dust containing small particles has long been of considerable importance in many industries. Increased concern about air pollution, with a resulting stressing of the importance of removing fly ash from flue gases, has caused engineers responsible for the generation of steam and for the design of equipment used in power generation to devote more attention to the physics of small particles. The growth in the use of pulverized-coal-fired and spreader-stoker-fired plants has complicated the problem of collecting particles of fly ash in the subsieve range. The techniques developed by metallurgists and others concerned with the determination of the size consist of extremely fine dusts and powders have thus been studied by engineers in the power field in an attempt to provide better equipment for the control of air pollution.

The many recent advances in the design of dust collectors have improved efficiency almost to the maximum for the collection of particles larger than 44 microns (325 mesh). With the attainment of this goal, more attention has been focused upon the improvement of collection efficiency for particles of smaller size. This problem has also been of importance because the use of more suspension-burning devices and of lower grade coals of finer size consist has produced flue dusts containing greater percentages of subsieve material than previously.

As more determinations were made of the size consist of fine particles of fly ash, some of the inherent difficulties of the common methods were discovered. Variations in reported size consists of fly ash from various types of combustion equipment caused concern on the part of those engineers responsible for the design and the operation of dust collectors. In an attempt to develop a common understanding of the problems involved and the techniques being used for the determination of subsieve size consist, Bituminous Coal Research, Inc., sponsored two meetings of representatives of dust-collector manufacturers early in 1951. Recognizing the basic problem of the accurate determination of size consist of small particles, these representatives agreed to analyze dupli-

cate samples of fly ash which were to be provided by Battelle on behalf of BCR. Companies participating in this program were the American Blower Corporation, Prat-Daniel Corporation, Research Corporation, and Western Precipitation Corporation.

Techniques for Subsieve Analysis

No report covering work of this type could be complete without the inclusion of some background material on the various methods used in determining size consist. Each of the methods used requires a lengthy discussion for full coverage of all of the important variables involved, but this material has been presented in the technical literature. Therefore, brief discussions are presented here of the more important methods in use today in order that the reader may keep these details in mind when evaluating the results reported.

The authors have not had first-hand experience with all of the methods described here; hence, the discussions may reflect this lack of familiarity. Inasmuch as the experience of the writers has been limited to a few devices, no one of the methods described can be recommended. The need for an evaluation of existing methods is discussed later in this paper.

Sedimentation

Of all the available methods for determining size consist of small particles, sedimentation is one of the most basic. In theory, the process is much simpler than others reported here. The determination of size consist by sedimentation requires first the choice of a liquid that will completely disperse the particles. Inasmuch as the method requires that each particle settle in the dispersing liquid independently of all other particles, it is important that no particles agglomerate. It is also important that each particle be thoroughly wetted over its entire surface, both external and internal (in the case of cenospheres), in order that the effect of minute air bubbles be eliminated.

The apparent specific gravity of the fly ash and the true specific gravity of the dispersing liquid must be determined accurately. Here again, for the fly ash, the factor of complete wetting of the external surface is important for accurate determinations.

After the dispersing liquid is chosen and the specific gravities of the liquid and the fly ash have been determined, the experimental technique is relatively simple. Although various types of apparatus are used for the determinations, the basic problem is that of measuring the time required for a sample to settle a known distance in the liquid. Stokes' Law related the settling velocity to the specific gravity of the particles and to that of the liquid, to the viscosity of the liquid, and to the equivalent diameter of the particle. Knowing the settling velocity, the equivalent particle diameter can be calculated.

Sedimentation analyses usually report size consists in a relatively wide band. It is common to report the results of such analyses as percentages in the ranges of 0 to 10, 10 to 20, and 20 to 44 microns. Obtaining small variations in equivalent sizes requires relatively little time, however. The accuracy of the determinations will increase as the number of times that a given sample is allowed to settle in the dispersing liquid.

Thus, it can be seen that the determination of size consist by sedimentation, though convenient, suffers from the following disadvantages:

1. Necessity to use a liquid that will effect complete dispersion and wetting of the entire sample for accurate determination of size consist.
2. Results are commonly reported in rather large size ranges, but could be reported in small ranges with little extra effort.
3. Convection currents caused by temperature differences and turbulence introduced as a result of improper technique can result in errors.

Air-Elutriation Devices

An example of an air-elutriation device is the Roller Analyzer. In operation, a sample of fly ash (about 15 cu cm in volume) is accurately weighed and placed in a U-tube which is connected to an air source and to a mechanical-type dust collector. The velocity of the air blowing through the U-tube and over the sample is first set for the lowest value desired; i.e., that velocity that will float off the dust of the smallest size fraction which is to be measured. This air stream is passed over the sample, which is mechanically agitated in the U-tube, for a given period of time (usually 30 min), after which the elutriated sample is removed from the collector and weighed. The procedure is then repeated using a higher velocity corresponding to the settling velocity of the next larger fraction desired. The blowing cycle and the removal of the collected sample are both repeated until nearly all the sample has been blown out of the U-tube.

The advantages of the Roller Analyzer are, first, simplicity of operation, and, second, the ease with which size consists in a band as narrow as 5 microns can be obtained. The following disadvantages of the device must be noted, however:

1. Necessity of cleaning the apparatus thoroughly after each blowing cycle to remove and weigh the extremely fine particles of dust.
2. Each size fraction requires 30 minutes to analyze.

Another elutriation device is the Infrasizer, which was originally developed for the determination of size consist in metallurgical testing. It has since been applied to the analysis of particles of many types, and has been used successfully for the determination of size consist of fly ash.

To quote the manufacturer's catalogue, "The Infrasizer is a laboratory batch instrument for splitting subsieve size powders into seven products, graded according to the settling rate of the particles in air. This is accomplished in six cones in series through which air is passed at an accurately controlled rate. The sample is placed in the first (smallest diameter) cone. The top of this is connected with the bottom of the next by rubber tubing, and so on from cone to cone. The cones are made of hard stainless steel, and the diameters at the top vary as the square root of two."

In operation, the sample is first dried thoroughly in an oven and weighed. The filter bag through which the air escapes from the last (and largest) cone is also weighed before the test. As noted above, the sample is then placed in the first (smallest cone). A constant flow of dried air is maintained through the Infrasizer for the desired length of time. The time factor is important; too little time will not allow a good separation of the sample, but, on the other hand, the separation will not be theoretically complete in any finite time. As a compromise, a period of one hour is usually chosen. At the end of the test, the

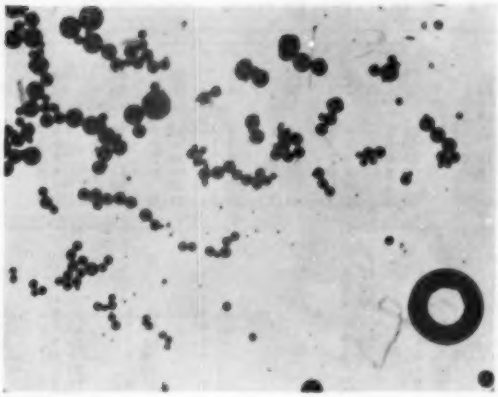


Fig. 3—Photomicrograph of hollow spherical particles of fly ash from standard sample

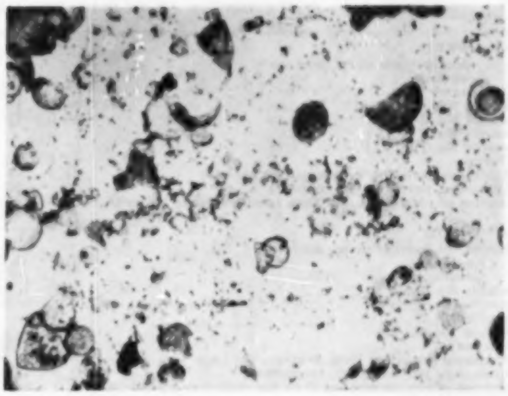


Fig. 4—Photomicrograph of crushed hollow spherical particles of fly ash from standard sample

product in each cone and filter bag is weighed.

The size consist of the particles in each of the products must be determined by microscopic count. The average micron size of the particles in each of the seven products, together with the weight percentage of the material collected in each of the cones, then gives the size consist of the sample.

The Infrasizer is not designed for, and hence will not give, a sharp size separation. For example, assume that the average size of the product from the sixth cone was 20 microns. Both the fifth cone and the filter bag would also contain some 20-micron material. This overlapping of sizes is not serious for the usual application of the Infrasizer to metallurgical work, but limits the use of the instrument for very accurate size-consist determinations.

Centrifugal Classifier

This device is relatively new in this country, having been first introduced in Sweden. The operation of the machine is described in the catalogs of one manufacturer, but no references have been found in the technical literature that evaluate the performance of the machine.

One classifier of this type operates as a combination centrifuge and air elutriator. The velocity of air through the machine can be adjusted by the insertion of various spacers. In operation, the entire sample is introduced into the center of the machine and to the outside of the spinning disk which is the major part of the machine. The air-flow direction is then reversed by 180 degrees. Only the particles having a terminal velocity equal to or less than the velocity around this turn can follow the air stream and be collected in the pan on top of the disk. Having determined the weight of the sample in this first size range, the remainder of the sample is put through the machine at a lower velocity. This lower velocity is obtained by replacing a small spacer element. The process of running a sample through the machine can be repeated up to eight times, each time with a different velocity, to obtain a complete size-consist determination.

It is obvious that this apparatus is a secondary standard, and must be calibrated against a primary standard (usually sedimentation analysis). The manufacturers advertise that, once calibrated with a sedimentation analysis, the reproducibility is excellent. Obviously, the calibration can be construed as being one of the weaknesses of the apparatus, in view of the difficulties in obtaining reasonably accurate sedimentation analysis data.

The chief advantage of a classifier of this type is that it does not require a skilled operator and gives a complete analysis of eight fractions in about two hours.

Microscopic Count

One verification of the size consist of a sample as determined by any of the means described previously can be obtained from a microscopic count. It is significant that none of the samples analyzed in this work were so counted. Yet this system is really a primary standard.

A microscopic count is performed by placing a sample on a microscope slide and actually measuring the size of the individual particles with a cross-hair and vernier attachment. A modification of the system is to project the field upon a screen so that the particles are enlarged to a greater magnification for more ease in counting.

The time required for performing a microscopic count is the chief drawback to a more extensive use of the procedure. Most commercial laboratories feel that the greater accuracy which can be obtained through the microscopic count is not warranted by the time required. It is unfortunate that no comparison between the results here reported and a microscopic count can be made to obtain a more thorough evaluation of these methods.

A serious disadvantage of this system is that only a plan view of each particle is obtained. Both the drag and mass of the particle calculated from dimensions obtained from a plan view can be seriously in error if the particle has an odd shape.

Another factor is that specific gravity must be measured to make the microscopic count results useful. This requires the choice of a dispersing liquid that wets all the surfaces of all of the particles.

Selection of Samples of Fly Ash

The main criteria for the choice of fly ash to be used as a standard would logically be first, an unlimited supply, and second, relatively uniform size consist over a period of time. Pulverized-coal fly ash taken from the electrostatic precipitators at one of the Detroit Edison Company's power plants would naturally meet the first requirement. Material from this source has also been reported[1] to maintain a uniform size consist.

[1] Yellott, J. I., Broadley, P. R., and Buckley, F. D., "The Coal-Burning Gas Turbine," *Proc.* Midwest Power Conference, 1951, pp 103–120.

TABLE 1.—SIZE CONSISTS OF DUPLICATE SAMPLES OF FLY ASH ANALYZED BY FOUR LABORATORIES

Laboratory	A				B							
Equivalent particle diam, microns												
Less than	10	20	44		7.5	10	15	20	30	40	60	
Greater than		10	20	44		7.5	10	15	20	30	40	60
Sample No. 1	54.6	15.6	20.6	9.2								
Sample No. 2	50.0	17.4	21.9	10.7								
Sample No. 9					32.0	6.4	12.4	8.4	12.9	10.6	8.7	8.6
Sample No. 10					30.0	7.1	15.6	7.1	16.4	8.5	9.5	5.8
Average	52.3	16.5	21.2	10.0	31.0	6.7	14.0	7.7	14.7	9.6	9.1	7.2
Maximum deviation from average, per cent	4.4	5.5	2.8	8.0	3.2	6.0	11.4	9.1	12.2	11.4	4.4	19.4
Equivalent particle diam, microns	10	20	44		7.5	10	15	20	30	40	60	
Amount of sample smaller than specified diam, per cent	52.3	68.8	90.0		31.0	37.7	51.7	59.4	74.1	83.7	92.8	

Laboratory	C					D			
Equivalent particle diam, microns									
Less than	3.6	6.4	15.3	31.5		5	10	20	
Greater than		3.6	6.4	15.3	31.5		5	10	20
Sample No. 5	4.5	11.0	33.5	21.2	29.8				
Sample No. 6	4.0	12.0	33.2	20.8	30.0				
Sample No. 7						30.2	24.4	20.9	24.5
Sample No. 8						35.3	20.7	20.6	23.4
Average	4.3	11.5	33.3	21.0	29.9	32.7	22.6	20.8	23.9
Maximum deviation from average, per cent	7.0	4.3	0.9	1.0	0.3	7.9	8.4	1.0	2.5
Equivalent particle diam, microns	3.6	6.4	15.3	31.5		5	10	20	
Amount of sample smaller than specified diam, per cent	4.3	15.8	49.1	70.1		32.7	55.3	76.1	

Fig. 1 is a photomicrograph (magnification 40×) of a sample of the Detroit Edison fly ash which was chosen as a standard.

Fig. 3 shows some of the lighter material contained in this fly ash, which was segregated by floating on acetone. This photomicrograph was also taken at a magnification of 40×. It is evident from this picture that the light particles which floated on the acetone are spherical.

Fig. 4 is another photomicrograph, at 100×, showing particles of fly ash which were deliberately crushed to show that the particles were hollow and could thus be accurately called cenospheres. Both Figs. 3 and 4 illustrate graphically the importance of wetting the inside surface of the particles, in the case of cenospheres, in order to obtain accurate determinations of both specific gravity and size analysis.

Fig. 2 presents, for comparison with the above three figures, a photomicrograph (at 40×) of fly ash from a spreader-stoker-fired installation. The comparison of this sample with the photomicrographs of the pulverized-coal fly ash is of interest because of the importance of proper installation of dust collectors on spreader-stoker-fired boiler furnaces.

A total sample of approximately 400 lb was obtained from the Detroit Edison Company, through the courtesy of W. A. Carter, for the selection of duplicate samples for this work. This sample was placed in a barrel which was tumbled and rolled to obtain thorough mixing. Eight one-quart cans were filled from the top four inches of fly ash in the barrel. Two cans were sent to the laboratories of each of the four dust-collector manufacturers participating in this program.

Results of Size-Consist Determinations

Table 1 presents the size-consist data reported by each of the four participating laboratories. These data are presented in this form chiefly to show the agreement obtained between the size consists of the two samples furnished each laboratory. Table 1 shows the maximum deviation from the average percentage undersize for each pair of samples. The fact that this maximum deviation is less than 10 per cent for most samples indicates either that the samples were good duplicates or that the techniques used yield moderately reproducible results.

Fig. 5 is a plot of the equivalent particle diameters as a function of the average percentage undersize, the data being taken from Table 1. This figure shows that the data as reported show a spread of some 25 percentage points. This is not too surprising when it is considered that the data as plotted were obtained using dispersing liquids of different specific gravity and were based on different determinations of the specific gravity of the fly ash. Fig. 5 illustrates the importance of making comparisons of this type only when all data are adjusted to a common denominator.

In order to adjust these data, it is necessary to refer to Stokes' Law, which is usually written as

$$V = \frac{2\, g\, r^2\, (d_p - d_1)}{9\, n}$$

in which

V = terminal velocity, cm per sec,
g = gravitational constant, cm per sec^2,
r = equivalent radius of particle, cm,
d_p = density of particle, g per ml,
d_1 = density of dispersing liquid, g per ml,
n = viscosity of dispersing liquid, poises.

The problem of adjusting reported data is simply that of calculating the size of particle that will have the same terminal velocity as that of a particle of a different density. For particles with the same terminal velocity in a given dispersing medium, it will be seen that

$$r \propto \frac{1}{(d_p - d_1)^{1/2}}.$$

Assigning the following additional subscripts,

t = values based on true specific gravity,
a = values based on assumed specific gravity,

the above proportionality may be expressed as follows:

$$r_t(d_{pt} - d_1)^{1/2} = r_a(d_{pa} - d_1)^{1/2}.$$

From this,

$$r_a = r_t\left(\frac{d_{pt} - d_1}{d_{pa} - d_1}\right)^{1/2}.$$

Table 2 shows the specific gravity data reported by each of the laboratories for both the fly ash and the dispersing liquids used. It is interesting to note that the fly-ash specific gravity determinations varied from 2.1 to 2.378. Equivalent particle diameters were arbitrarily adjusted to a specific gravity of 2.0. The adjusted particle diameters reported in Table 2 were obtained by using

TABLE 2.—SUMMARY OF SPECIFIC GRAVITY DETERMINATIONS AND PARTICLE DIAMETERS ADJUSTED TO SPECIFIC GRAVITY OF 2.0

Laboratory	A		B	C		D	
Sample No.	1	2	3, 4	5	6	7	8
Specific gravity reported:							
Fly ash	2.36	2.33	2.1	2.24	2.22	2.367	2.378
Liquid	0.80	0.80	*	*	*	0.821	0.821
Equivalent particle diam, microns	10 20 44	10 20 44	7.5 10 15 20 30 40 60	3.6 6.4 15.3 31.5	3.6 6.4 15.3 31.5	5 10 20	5 10 20
Factor to adjust particle diam to common specific gravity	1.140	1.128	1.118	1.059	1.052	1.145	1.150
Adjusted particle diam, microns	11.4 22.8 50.2	11.3 22.6 49.6	8.4 11.2 16.8 22.4 33.5 44.6 67.0	3.8 6.7 16.2 33.3	3.8 6.7 16.1 33.2	5.7 11.5 22.9	5.8 11.5 23.0
Average adjusted particle diam, microns	11.3 22.7 49.9		8.4 11.2 16.8 22.4 33.5 44.6 67.0	3.8 6.7 16.1 33.2		5.8 11.5 23.0	

* (Air used)

the formula above. Inasmuch as the size consists as determined by screening would not be affected by the specific gravity adjustment, these data are not included.

Fig. 6 presents a plot of the average percentage undersize (as reported in Table 1) as a function of the adjusted equivalent particle diameters shown in Table 2. Comparison of Figs. 5 and 6 shows that the effect of adjusting particle diameters was to shift the curves downward while slightly reducing the spread of the points.

Terminal-Velocity Comparisons

Dust-collector manufacturers have long recognized the importance of determining terminal velocities for samples of fly ash. Most persons not closely associated with the field have usually thought of the problem of collecting fly ash from the standpoint of the size of the particles involved rather than the primary variable of terminal velocity. A comparison of the terminal velocities obtained by the laboratories participating in this program is thus in order.

Fig. 7 shows the variation of the amount of fly ash in suspension at various velocities for three determinations. Data for Fig. 7 were obtained by calculations from test information reported by the manufacturers. The curves for Laboratories C and D, respectively, were computed by an adaptation of the equation for Stokes' Law.

Significance of Comparison of Results Reported

As previously pointed out, the good agreement obtained by each laboratory on the size consists of the two samples analyzed indicates good analytical technique and confirms the validity of the method of obtaining the original duplicate samples. The reproducibility of the results is satisfactory with existing techniques and equipment when used in one laboratory.

The importance of correct specific gravity determinations for both fly ash and liquid has been discussed in this report. This must be stressed, however, because of the difficulty in making these determinations. The choice of a liquid which will effect complete dispersion of the fly ash is often a major problem. For example, in performing sedimentation analyses on a spreader-stoker fly ash

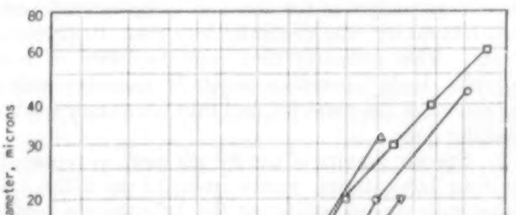


Fig. 5—Average size consists of duplicate samples of fly ash analyzed by four laboratories (from Table I)

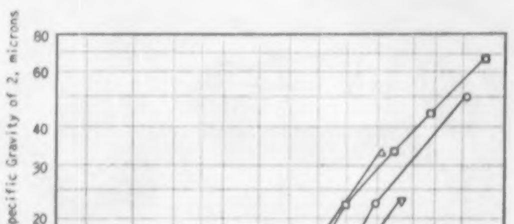


Fig. 6—Average size consists of duplicate samples of fly ash adjusted to common specific gravity

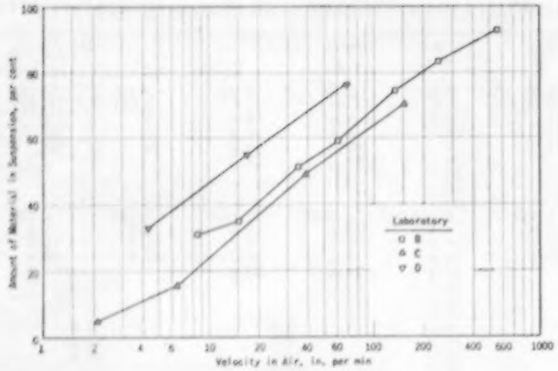


Fig. 7—Percentage of material in suspension as a function of terminal velocity for three analyses

at Battelle (with a different sample than that used in the work here reported), some 40 liquids were tested, none of which was suitable. It is often difficult to determine whether complete wetting of all of the surfaces of the particles is being obtained. Experience at Battelle indicates that no one liquid can be regarded as the universal dispersing agent, but that each sample of fly ash must be tested with a number of liquids in an attempt to find one suitable. Even then there is no assurance that the cenospheres will be filled to result in an accurate analysis.

The difference between the curves of Fig. 6 cannot be attributed to variations in specific gravity alone, however. It can be shown that a recalculation of equivalent particle diameter based on the range of specific gravities possible for both fly ash and liquid will shift the size consist plots only slightly. Thus the basic theories of these methods of determining size consist must be re-examined to find an explanation for the wide divergence in results.

Stokes' Law was derived mathematically for solid, spherical particles. In the absence of a more logical assumption, this law has been used without modification for the determination of settling velocity of heterogeneous particles. Laboratory experience has shown that Stokes' Law yields accurate and reproducible results when dealing with solid, spherical particles. Yet fly ash can be considered only a heterogeneous mixture of solid spherical particles, hollow spherical particles, coarse irregularly shaped lace-like particles, broken hollow spheres, and the like. This is well shown in the photomicrograph of Fig. 4.

The most significant observations resulting from this study are probably those connected with the interpretation of Fig. 7. Although the shape of the three curves is the same, the spread between the curves is disturbing. For a given terminal velocity, Fig. 7 shows a difference of about 20 percentage points in the amount of material settled. This would certainly be a significant difference if a collector were being designed on the basis of either of the extremes shown. It would appear that a collector so built would either be underdesigned, and operate inefficiently, or be overdesigned at a needless expense.

It should be pointed out that it is more important to obtain the terminal velocity of particles falling in air, rather than to perform sedimentation determinations in a liquid and convert the results to determine terminal velocity in air. It is evident that much more work needs to be done to find the correct method of determining terminal velocity.

Conclusions

The work reported may be summarized as follows:

1. The maximum deviation from the average of the percentage undersize for the two samples analyzed by each laboratory was generally less than 10 percentage points. This indicates that reproducibility of results within a single laboratory naturally increases with the size consist of the particles, and that laboratory work was carefully done.
2. Specific gravity of the fly ash used, as reported by the four laboratories, varies from 2.1 to 2.378. This rather wide spread points out the difficulties in performing this determination.
3. A comparison of terminal velocities calculated from data reported showed a difference of about 25 percentage points between the limits in the amounts of material settled at any given terminal velocity. The variation in particle sizes, which were calculated from terminal velocities, was of the same order.
4. The degree of agreement of the data indicates both the difficulty of performing sub-sieve size-consist determinations and the need for improved instrumentation.

Future Work

The results of this work indicate the need for further study of the problem of obtaining accurate size-consist determinations of fly ash

*Case History of an 850-psig Topping Turbine Installation**

By H. R. EMERY and P. L. NELSON

St. Regis Paper Co. Chas. T. Main, Inc.

Steam and power generating equipment in many of the older pulp and paper mills in the country is obsolete, inefficient and approaching the end of its useful life. The modernization of a typical old steam power plant at the Deferiet mill of the St. Regis Paper Co. is discussed. The case history covers: (1) the original steam plant and previous changes made in it, (2) engineering studies preceding the actual installation, (3) equipment installed in the new steam power plant, (4) preliminary operating problems encountered, and (5) present-day operating costs of the new power plant.

THE Deferiet, N. Y., mill is the original mill of the St. Regis Paper Co. This mill, completed in 1901, was described in the newspapers of that day as a "gigantic manufacturing institution." Installed equipment included four paper machines with widths varying from 90 to 145 in. The boiler house contained twenty 100-hp Watertown Iron Works boilers grouped in batteries of five and hand fired. Four Watertown Engine Co. 300-hp reciprocating steam engines were installed in the engine room, their power being transmitted by belt and lineshaft to the machines. Three 500-light generating units were installed for electric power, these being driven through a rope drive either by steam engine or water power.

Previous Changes in Steam Power Plant

The mill started up and operated on the above-listed steam and power equipment until 1913 when two 610-hp, 150 psig, Sterling-type, stoker-fired boilers were installed in battery. In 1915 Nos. 3 and 4 boilers were installed, followed by Nos. 5 and 6 in 1921; all were the same size and type of Sterling boiler. Of the 20 original Watertown Iron Works boilers installed in the mill, two are still in operation as bark, sawdust, and trash burners in the small boiler house in the yard. The others were junked or scattered over a considerable portion of the northern New York area for various types of service.

During the years 1924 to 1927 the reciprocating drives on the four paper machines were replaced with individual turbine drives. Boiler Nos. 3, 4, 5 and 6 were redesigned for pulverized coal firing; size F Aero pulverizers were installed on each boiler; and superheaters giving 80 deg F superheat were added. Nos. 1 and 2 were relegated to an emergency standby basis.

In 1925 the Central New York Power Co. installed a 5000-kw condensing turbine-generator in a power-house built on the mill premises adjacent to the boiler house. This was operated by the utilities during times of the year when low river flow limited the power output of their hydroelectric plants. Steam to operate this turbine-generator unit was purchased from St. Regis Paper Co.

No further changes in the steam and power systems were considered until 1936 when, due to the age of the operating boilers, it became apparent that new steam generating equipment would soon be required.

Engineering Studies Previous to 1940

In the years between 1936 and 1939, steam and power surveys were made by several engineering concerns. Four basic recommendations of major surveys for the installation of new steam and power generating equipment are tabulated in Table I.

Although the results of these studies were presented to the management, no action on purchasing new boilers could be taken. One recommendation made as a result of these studies was to purchase the 5000-kw condensing turbine-generator from the Central New York Power Co. This recommendation was followed, and the unit was purchased by the St. Regis Paper Co. in 1936.

In 1939 additional surveys of the steam and power systems resulted in three more basic recommendations. The results of these additional studies are in Table II.

This second set of studies was advanced for the consideration of management, and again no action could be taken on the power expansion program. However, the results of the various surveys have been listed in outline form to show that the management of the mill was continually exposed to the thinking of the consulting engi-

* Presented at the Eighth Engineering Conference of the Technical Association of the Pulp & Paper Association, Montreal, Que., Oct. 26–29, 1953. Abridged from May 1954 issue of *TAPPI*.

TABLE I—SUMMARY OF SURVEYS MADE IN 1936

Survey No.	Recommended Boiler	Recommended Turbine-generator	Estimated Investment	Gross Yearly Savings	Remarks
1	One 100,000 lb per hr, 500 psig, 750 F	One 3000-kw noncondensing	$389,000	$126,000 (32.4%)	Includes electrified paper machine drives
2	One 100,000 lb per hr, 600 psig, 850 F	One 3500-kw noncondensing	$436,000	$137,000 (31.4%)	Includes electrified paper machine drives
3	One 100,000 lb per hr, 900 psig, 900 F	One 4000-kw noncondensing	$501,000	$158,000 (31.6%)	Includes electrified paper machine drives
4	One 100,000 lb per hr, 1400 psig, 900 F	One 5000-kw noncondensing	$560,000	$173,000 (30.9%)	Includes electrified paper machine drives

The above studies were based upon: (*a*) delivered cost of coal = $4.60 per ton; (*b*) average cost of purchased electric power = 0.6¢ per kwhr; (*c*) number of paper machines at the mill = 4.

TABLE II—SUMMARY OF SURVEYS MADE IN 1939

Survey No.	Recommended Boiler	Recommended Turbine-generator	Estimated Investment	Gross Yearly Savings	Remarks
1	One 120,000 lb per hr, 900 psig, 825 F	One 5000-kw double extraction, noncondensing	$544,000	$178,000 (32.8%)	New turbine to drive 5000-kw generator purchased from utilities
2	One 120,000 lb per hr, 900 psig, 825 F	One 7500-kw noncondensing (topping)	$758,000	$262,000 (34.5%)	Includes electrified paper machine drives
3	One 200,000 lb per hr, 500 psig, 660 F	One 5000-kw noncondensing (topping)	$726,000	$256,000 (35.3%)	Eliminates purchase of electric power

neers, and that the recommendation of the consulting engineers was toward continued higher operating pressures for industrial steam power plants.

In 1940 a fifth paper machine was installed at the mill, and went into service in August of that year.

Studies Immediately Preceding the Installation

In 1940 the consulting engineers from Chas. T. Main, Inc., made their first engineering survey at the Deferiet mill. Their original recommendations, based upon the steam and power requirements of the mill with the five paper machines, were as follows:

1. Install two 70,000 lb per hr pulverized-coal-fired boilers to operate at 600 psig, 750 F.
2. Install one 3000-kw noncondensing turbine-generator unit to take steam at 600 psig, 750 F at the throttle and exhaust at 150 psig to the pulp and paper mill and to the existing 5000-kw condensing unit.
3. Remove the existing Sterling (Nos. 1, 2, 3 and 4) boilers to make room for the two new boilers.
4. Retain the existing Nos. 5 and 6 boilers in service as emergency standby equipment.

The investigated investment required was $389,000 resulting in a gross yearly saving of $79,000 (20.3%).

Again economic conditions apparently stopped the management from taking the proposed steps to purchase the new power equipment. The advent of World War II stopped any further moves in this direction for the next 4 years. The State Department of Labor, after proper hydrostatic tests, allowed the six existing Sterling boilers to be operated at design pressure through the war years with the provision that steps would be taken to replace them as soon as materials became available.

In 1944 Westinghouse Electric Corp. made an independent survey of the steam and power needs of the mill, and came up with recommendations that followed very closely those made by Chas. T. Main, Inc., in 1940.

Plans were made in 1944 for increased paper production at the mill. Installation of the No. 6 paper machine was authorized, and the possibility of a seventh machine in the future was considered. Plans also included changed types of paper. Since any study of mill steam and power requirements is no more accurate than the pulp and paper tonnage figures used in making the study, it was necessary to revise the previous power surveys in order to meet the power requirements of the proposed increase in mill output. Consequently Chas. T. Main, Inc., was retained in 1944 to revise their 1940 report to take into account the increase in steam and power requirements. This final report was based upon the following production figures.

Paper production (seven machines)	306 tons per day
Groundwood pulp production	150 tons per day
Sulfite pulp production	100 tons per day
Bleach production	100 tons per day

From these production figures the average steam and power requirements were estimated. The estimated power requirements are tabulated in Table III, and the estimated process steam requirements are tabulated in Table IV.

Using these estimated quantities of steam and power, several sizes of equipment and combinations of the sizes were considered. The final choice was made from the four possible schemes of development outlined in Table V.

Scheme four consisting of two 100,000-lb per hr boilers at 800 psig, 825 F. and one 6000-kw noncondensing turbine-generator was the recommendation made by Chas. T. Main, Inc., to the St. Regis Paper Co. as the first step of a long range steam and power expansion program. The full recommendation was to complete the expansion in three steps as follows, the last two steps being deferred into the future.

Step 1—to be done as soon as possible.

1. Install two 100,000-lb per hr pulverized-coal-fired boilers to operate at 850 psig, 850 F.
2. Install one 6000-kw noncondensing turbine-generator unit to take steam at 800 psig, 825 F at the throttle and exhaust at 150 psig to the pulp and paper mill and to the existing 5000-kw condensing unit.
3. Remove existing Nos. 1, 2, 3 and 4 boilers to make room for the two new boilers.
4. Retain the existing Nos. 5 and 6 boilers in service as emergency standby equipment.

Step 2—to be done when Nos. 5 and 6 boilers are condemned.

1. Install a third 100,000-lb per hr boiler similar to the first two installed under step one.
2. Remove existing Nos. 5 and 6 boilers to make room for the third 100,000-lb per hr unit.

Step 3—to be done if ever justified economically. Based on the economics of future purchased power contracts.

1. Install a fourth 100,000-lb per hr boiler similar to the first two installed under step one.
2. Install two additional 6000-kw turbine-generators to permit the mill to generate all required electric power.

The definite decision to go ahead with step 1 of the recommended program was made early in 1945, and design of the installation commenced at once. A simplified schematic diagram of the modernized steam power plant is shown in Fig. 1. It has not yet been necessary to proceed with step two or step three of the program.

TABLE III.—ESTIMATED ELECTRIC POWER REQUIREMENTS

Average Production Tons per Day	Material	Per Unit Electric Energy, Kwhr per Ton	Total Electric Energy, Kwhr per Day
306	Paper	670	205,000
150	Groundwood pulp	1400	210,000
100	Sulfite pulp	170	17,000
100	Bleach	120	12,000
			444,000

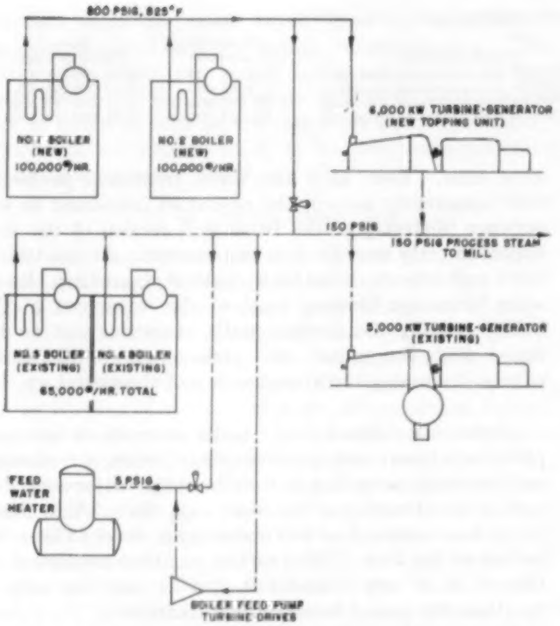


Fig. 1 Schematic diagram of modernized steam plant

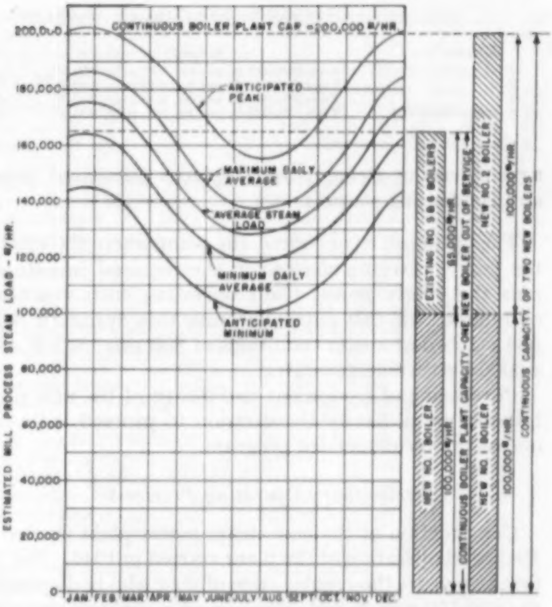


Fig. 2 Comparison of anticipated steam loads and boiler capacities

Basis for Recommendations

In order to present the picture in a readily understandable form, the anticipated steam loads were compared graphically to the recommended boiler capacities. This is indicated in Fig. 2. The steam load curves show:

1. The variation in the average steam load during the course of an average year. This curve is labeled "average steam load."
2. The amount the average steam load may be expected to exceed the monthly average on any given day. This curve is labeled "maximum daily average."
3. The amount the average steam load may be expected to fall below the monthly average on any given day. This curve is labeled "minimum daily average."
4. The variation in the instantaneous peak steam load during the course of the year. This curve is labeled "anticipated peak."
5. The variation in the instantaneous minimum steam load during the course of the year. This curve is labeled "anticipated minimum."

Bar graphs representing continuous boiler capacities have been included adjacent to the steam load curves to show:

1. The 200,000-lb per hr total continuous capacity of the two new boilers exceeds the maximum daily average steam load in the winter by about 14,000 lb per hr, or roughly 7 per cent.:
2. In the summer months with one of the new boilers at a time off the line for the annual inspection and maintenance period, the entire mill steam load can be carried by the remaining new boiler plus Nos. 5 and 6.

The logic of the selection of the two 100,000-lb per hr boilers, whose combined capacities exceed the maximum steam load by a small margin, is evident from this graph. Also the existing Nos. 5 and 6 boilers are available either as standby steam capacity for the new boilers or to produce 150-psig steam for use in the existing 5000-kw condensing turbine if condensing power should ever be required in the winter months.

In selecting the operating pressure and temperature for the new boilers and the kilowatt rating of the new turbine-generator, curves similar to those shown in Fig. 3 were used. These curves represent three of the many possible combinations of steam pressure, steam temperature and turbine-generator size that were studied. In general in installations of this type, as the throttle steam pressure and temperature of the topping unit are increased, it is true that:

1. For any given steam load, more noncondensing power will be produced and a larger turbine-generator will be required. This is evident from the curves of Fig. 3.
2. The capital investment required will be increased by the need for higher pressure equipment and a larger turbine-generator.
3. The yearly operating costs will be decreased as

TABLE IV—ESTIMATED AVERAGE PROCESS STEAM REQUIREMENTS—DEFERIET MILL

Average Production Tons per Day	Material	Average per Unit Steam Usage, Lb Steam per Ton	Total Process Steam Load, Lb Steam per Day: Average	Summer	Winter
306	Paper	9000	2,754,000	2,400,000	3,000,000
100	Sulfite pulp	6000	600,000	500,000	700,000
100	Bleach	3000	300,000	200,000	400,000
		Daily total	3,654,000	3,100,000	4,100,000
		Hourly average	(152,000 lb per hr)	(129,000 lb per hr)	(171,000 lb per hr)

TABLE V—SCHEMES OF DEVELOPMENT CONSIDERED IN 1944—DEFERIET MILL

Scheme No.	Boilers	Turbine-generator	Estimated Investment	Gross Yearly Savings
1	Two 100,000 lb per hr, 600 psig, 750 F	One 4000-kw noncondensing (topping)	$850,000	$120,000 (14.1%)
2	Two 100,000 lb per hr, 600 psig, 750 F	One 5000-kw noncondensing (topping)	$880,000	$130,000 (14.8%)
3	Two 100,000 lb per hr, 800 psig, 750 F	One 5000-kw noncondensing (topping)	$1,000,000	$154,000 (15.4%)
4 (recommended)	Two 100,000 lb per hr, 800 psig, 825 F	One 6000-kw noncondensing (topping)	$1,035,000	$164,000 (15.8%)

noncondensing steam power replaces purchased power and condensing steam power.

The optimum is, of course, the point where the total of the yearly carrying charges on the required investment plus the yearly power plant operating costs reaches a minimum. In this particular case this optimum point was reached at steam conditions of 800 psig, 825 F with a 6000-kw turbine-generator.

Purchasing of equipment and design of the new plant followed immediately the decision to proceed with step one of the recommended program.

Preliminary Operating Problems

Construction of the new steam power plant started in 1945, and operation of the plant started in 1946. For the first two years the regular crew of men who had operated the old 150-psig boilers were apprehensive and unsure of themselves while operating the modern, high-pressure equipment. Continued checking gradually uncovered the causes of the initial operating difficulties. The major troubles encountered were as follows:

1. In spite of previous pulverized coal experience in the boiler house, one furnace explosion occurred which required replacement of much of the furnace brickwork.
2. Water treating problems, with both the automatic controls and the types of treatment, were unsettled for some time. Even after the water treatment problems were apparently solved, the operators continued to experience blistering of the front wall section of the new boilers directly over the top two burners. At one time a front wall tube ruptured for a length of about 12 in. due to scale formation blowing most of the water out of the boiler, bulging the furnace walls, drowning out an induced draft fan motor, and perhaps one of the worst effects, increasing the apprehension of the operators.

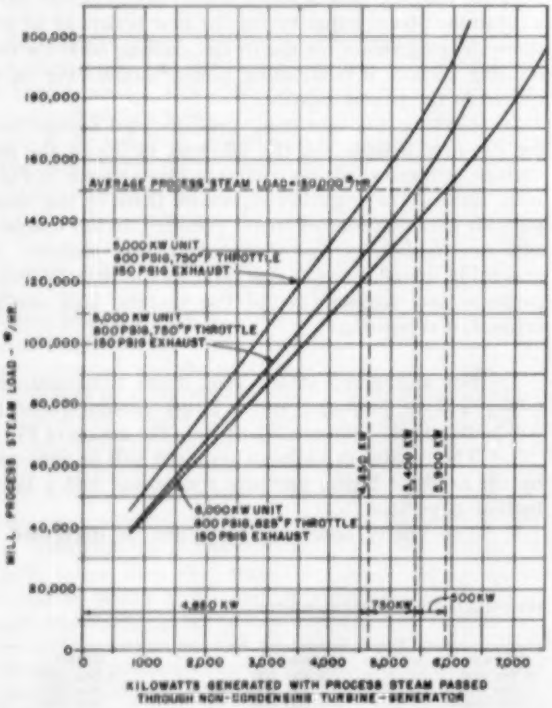


Fig. 3 Relationship of anticipated steam loads to power generation

Mechanical failures in the boiler internals of feed and phosphate lines causing uneven distribution of feedwater and chemicals seem now to have been the major contributors to the blistering of the front wall tubes. Acid cleaning at least once a year was necessary in order to keep the boilers on the line. This practice has been continued although it is now considered that it may be safe to lengthen the period between acid treatment.

Water treatment went through several changes and evolved the following present practice:

River water enters chemical treatment at the clarifier where it is coagulated with alum and sodium aluminate. Much of the color and suspended solids are removed by the coagulation. The clear effluent is then filtered by gravity and softened by sodium cycle zeolite. At this point the water is practically at zero hardness, but for high pressure boiler use it must be further treated to prevent corrosive action on boiler system metals. Flake caustic is added to the roof tank storage to maintain feedwater at a high alkaline condition. Roof tank water flows to the condensate tank, where the mixing of the two waters makes up the feedwater for the boilers. The feedwater is pumped to the deaerator where oxygen is removed, then into the heater tank, at which point sodium sulfite is added, to remove the last traces of oxygen. Nalco 75, a lignin derivative compound which

TABLE VI—COST OF STEAM AND POWER—COMPARISON OF OLD EQUIPMENT VERSUS NEW EQUIPMENT

	Total Steam 1000 Lb per Yr	Total Electric Energy 1000 Kwhr per Yr	Total Cost $ per Yr
1945 Boiler House and Electric Generating Equipment			
Present mill process steam generated with 1945 equipment	1,179,395		$ 877,200
Purchased electric power		123,935	1,022,394
Total cost of steam and electric power			$1,899,594
Present Boiler House and Electric Generating Equipment			
Present mill process steam	1,179,395		
Steam to generate electric power	516,332		
Total steam generated	1,695,727		$1,047,593
Electric power total, purchased and generated (exclusive of steam required)		124,680	597,037
Total cost of steam and electric power			$1,644,630
Annual Saving in Total Steam and Power Cost			
$1,899,594 less $1,644,630			$ 254,964
Cost of Steam and Power per Ton of Paper			
			$ per Ton of Paper
1945 equipment (1,899,594/92,900 tons)			$20.45
Present equipment (1,644,630/92,900 tons)			17.70
Savings per ton of paper			$ 2.75

prevents scale formation when used in an alkaline medium, is added with the sodium sulfite solution. The last chemical addition to the water takes place in the steam drums of the boilers where sodium phosphate solution is added to remove the last trace of calcium hardness. Internal inspection for the last two years has indicated that this is successful.

Present-day Operating Costs

The total cost of the new steam power plant, plus the cost of improvements and additions to the electrical distribution system not discussed here, was about $1,900,000. Comparisons of savings effected by the change are difficult to make due to rapidly changing economic conditions. However, to illustrate the difference between the yearly cost of steam and power using the old equipment available in 1945 and the yearly cost using the present equipment, Table VI has been prepared. The cost figures in Table VI are based upon quantities of steam and electric power used for the year June 1952 to June 1953 plus current labor and fuel rates.

The reference literature, "Selection of Steam Pressures and Temperatures for Paper Mill Power Plants"*, has been used to calculate the over-all thermal efficiency of the new steam power plant. Using Fig. 4 of the reference literature plus the following data gives:

Steam to main condensers	340,332,000 lb per yr
Total boiler steam output	1,695,727,000 lb per yr
Per cent of total steam output to condensers	20.1%
Power plant thermal efficiency	63%

During the past year an increase in the purchased electric power rate has made the cost of condensing steam power lower than the cost of purchased electric power. As condensing power replaces purchased electric power, the power plant thermal efficiency will, of course, be reduced due to the increased heat loss to the condenser.

Dollars return per year on the new power plant are higher than originally predicted due to the increased cost of purchased electric power since the installation was made. The original savings were based upon a purchased power cost of 0.4 cent per kwhr as compared to a present cost of approximately 0.8 cent per kwhr.

* Dixon, M. H., W. C. Bloomquist and W. B. Wilson, *Tappi*, Vol. 33, No. 7, July 1950, pp. 305–312.

Principal Power Plant Equipment

Steam generating equipment, including pulverizers	Combustion Engineering, Inc.
Air preheaters	The Air Preheater Corp.
Induced draft fans	The Green Fuel Economizer Co., Inc.
Forced draft fans	The Green Fuel Economizer Co., Inc.
Magnetic coupling for i-d fans	Dynamatic Corp.
Pulverizer and fan motors	Allis-Chalmers Mfg. Co.
Dust collectors	Western Precipitation Corp.
Soot blowers	Diamond Power Specialty Corp.
Turbine-generator	Westinghouse Electric Corp.
Coal handling equipment	Link-Belt Co.
Coal bunker	Connery Construction Co.
Coal bunker gates	Stephens-Adamson Mfg. Co.
Automatic coal scales	Richardson Scale Co.
Ash and dust handling equipment	United Conveyor Corp.
Deaerating heater	Cochrane Corp.
High-pressure heater	American Locomotive Co.
Boiler feed pumps	Ingersoll-Rand Co.
Boiler feed pump turbines	General Electric Co.
Feedwater regulators	Copes
Continuous blowdown system	Henszey Co.
Water treatment	Infilco, Inc.
Chemical feed pumps	Milton Roy Co.
Water treating consultant (present)	National Aluminate Corp.
Combustion control	Hagan Corp.
Recording meters	Bailey Meter Co.
Flues and ductwork	Connery Construction Co.
Oil purifier	Bowser, Inc.
Structural steel	American Bridge Co.
Piping	National Valve Co.
Compressors	Pennsylvania Pump & Compressor Co.
Pressure reducing and desuperheating	Swartwout Co.
Building and structure	George A. Fuller Co.
Consulting Engineers	Chas. T. Main, Inc.

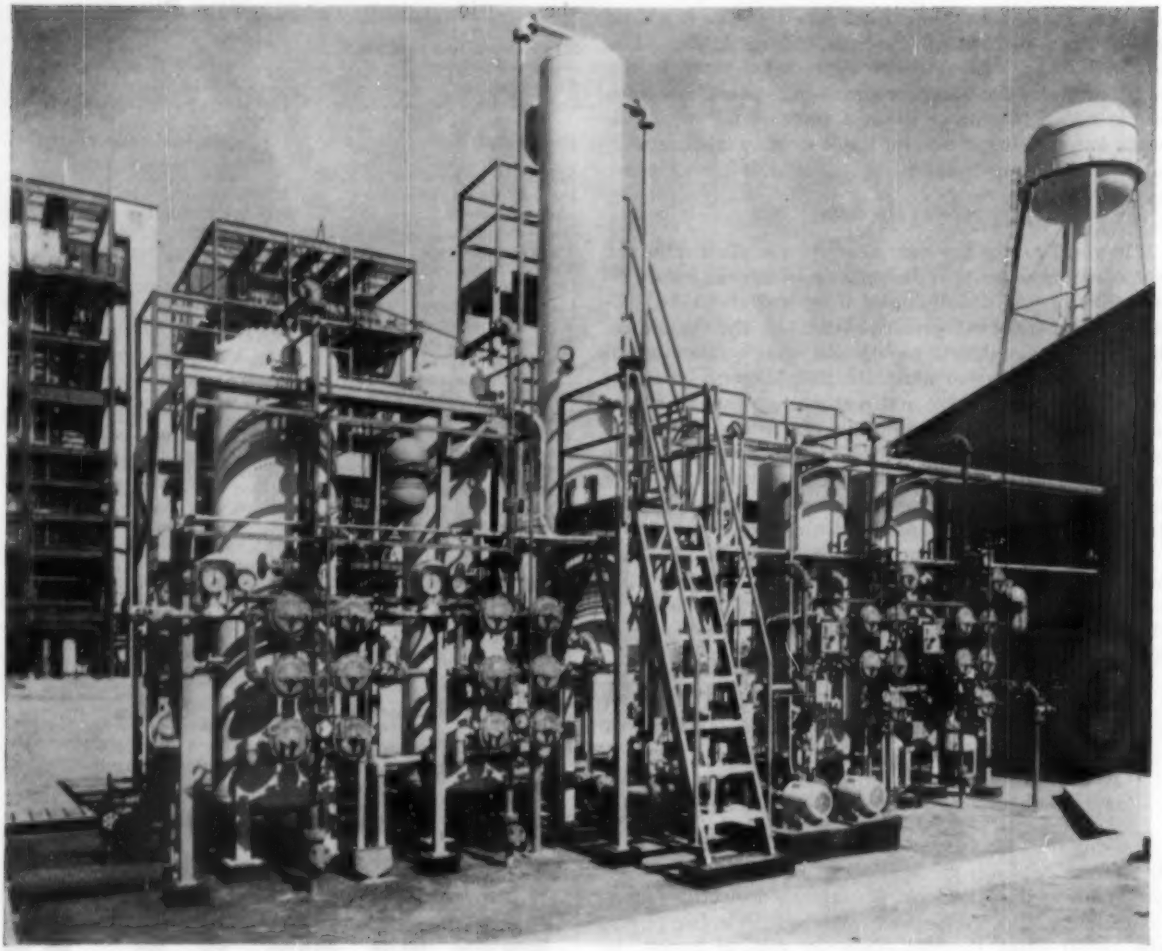


Fig. 1.—Fully automatic 1800 gph two-bed demineralizer vacuum degasifier stands between anion cation units

The Status of Demineralizing In Today's Plants*

The application of demineralization to boiler feedwater treatment has proved sound and economical. This account puts a statistical value on the number of installations to date and supplies helpful curves for estimating costs and performances of the systems now on the market.

By

V. J. CALISE

Graver Water Conditioning Co.

ALTHOUGH there are many new developments of interest in feedwater treatment for central station plants including improved deaerating heaters, short retention clarification equipment and automation of equipment generally, an interim report on demineralizing warrants attention.

In the last four years a considerable amount of demineralized water has been produced and utilized in central station and industrial power plants throughout the country by the use of multi-bed and mixed bed ion-exchange demineralizers. A consideration of four principal areas points up today's situation and can be of great value in appraising developments in the next few years. These areas are:

1. Approximate number, flow and type of demineralizers as compared to evaporators installed in power plants to date.

* Presented before Southeastern Electric Exchange Meeting, Miami—May 7, 1954

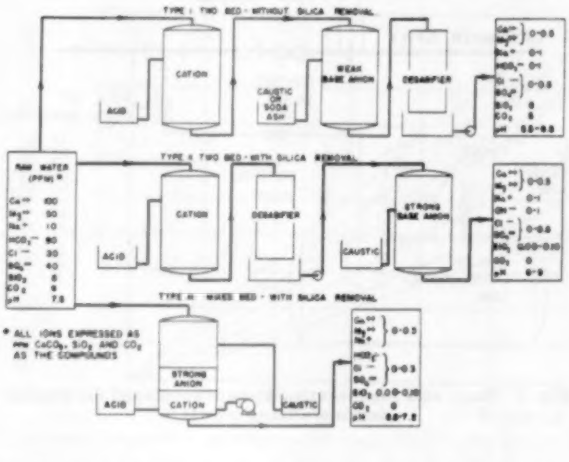


Fig. 2—Basic types of demineralizers, above, include Type I, lowest chemial costs but no silica removal; Type II, as effective as Type I plus silica and carbon dioxide removal; Type III, most complete removal of strong electrolytes, silica removal optional

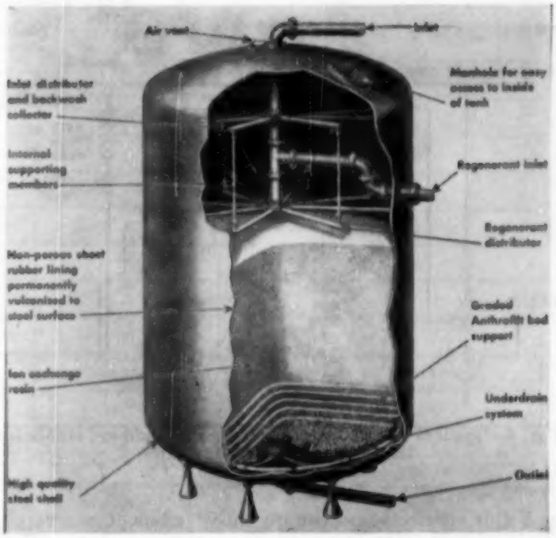


Fig. 3—Cutaway view of a large ion-exchange unit with all parts labeled. Special emphasis is accorded the distribution system to avoid short-circuiting or channeling

2. Where the demineralized water is fed into the feedwater cycle.
3. Arrangements used for chemical regenerant handling.
4. Automation of operation, instrumentation and controls.

Number, Flow and Type of Demineralizers

Acid regenerated cation exchangers of the phenolic or coal type became commercially practicable about 1937. Weakly basic anion exchangers and demineralizing, as we know it, were made practicable in 1940. In 1946 strongly basic anion exchangers to reduce silica and CO_2, as well as strong electrolytes, were promoted.

As of the present time approximate industry-wide statistics on ion-exchange plants of various types for feedwater treatment for both industrial power plants and central station utilities follow the breakdown in Table I.

With such data serving as a background we feel a fair presentation of facts would show between one and two demineralizers used for central station high pressure boiler makeup to every four or five evaporators on low makeup units. Where total makeup flow runs substantially above 50–75 gpm demineralizers constitute an even higher percentage relative to evaporators because of generally lower equipment cost advantages, particularly on lower solids water.

Advantages of demineralizers over evaporators that have made them quite popular with utilities are: (1) higher purity of effluent from demineralizer over evaporator, (2) no need for steam bleed for operation of demineralizer, (3) lower operating costs with demineralizer due to lower chemical costs and less energy degradation, (4) lower equipment costs especially in the higher makeup flows above 50 gpm.

TABLE I—PRESENT-DAY ESTIMATES OF ION-EXCHANGE UNITS IN CENTRAL STATION AND INDUSTRIAL SERVICE

A—Greensand sodium zeolite softeners	10,000–15,000
B—Siliceous sodium zeolite softeners	3,000– 5,000
C—Styrene and phenol base resin & coal base sodium zeolite softeners	4,000– 6,000
D—Hydrogen cation exchange with sodium zeolite	500– 700
E—Weakly basic anion demineralizers	250– 350
F—Strongly basic anion demineralizers with silica reduction	250– 350

Recent installations of demineralizers indicate the mixed bed type applies wherever higher solids raw waters like those in the Southwest, Far West and Midwest are encountered. Also where extreme purity of 4,000,000 ohms-cm resistance as well as 0.02 ppm silica is desired, such as with boiler pressures above 2000 psig, the mixed bed type is chosen.

With lower solids waters, such as in the Southeast, however, 2-bed demineralizers or even 4-bed units come into their own. Treated water usually runs 1–2 micromhos purity with less than 0.02 ppm silica with such multi-bed units.

The preservation of optimum long term operating performance on both mixed bed and multi-bed demineralizers involves: (*a*) selection of proper type of anion exchange resin—Type II resins for waters of high percentage strong acids to weak acids; Type I for waters of high percentage of weak acids (*b*); supplying a very clear, organic-free water to the demineralizer; (*c*) proper regeneration conditions; (*d*) possibly lower oxygen in the water in contact with the anion resins.

Demineralized Water Entrance Into Cycle

Two-bed demineralizers usually employ degasifiers or vacuum deaerators to remove carbon dioxide (see Fig. 2). The forced draft aerator or degasifier saturates the water with oxygen by blowing filtered air through the water. The cold water vacuum deaerator removes both oxygen (down to 0.1 ppm) and carbon dioxide (to less than 1 ppm). Its use is preferred over the degasifier for these reasons:

It removes oxygen from the water as well as carbon dioxide, instead of saturating it with air, and thereby reduces the oxygen load on all other oxygen removing units in the system including turbine condenser and deaerator.

It permits introduction of cold water into the cycle

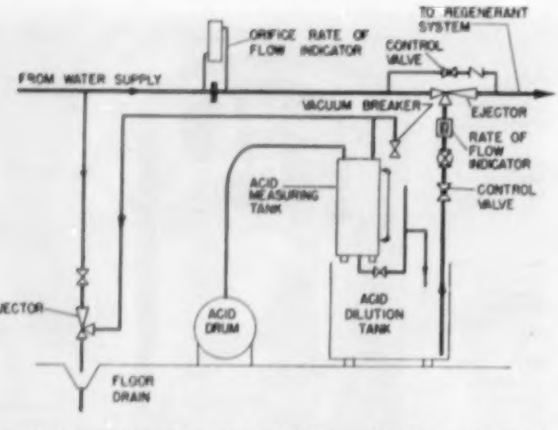


Fig. 4—Typical storage and handling of acid or alkali for larger demineralizing plants

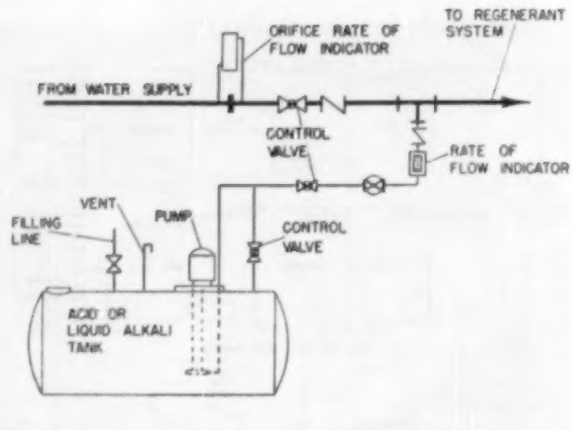


Fig. 5—Basic acid regenerating system employed for smaller demineralizing plants

and this permits maximum heat efficiency, overall.

In some cases the vacuum deaerated water at a pH of 8.0–8.5 from a 2-bed unit can be discharged directly into a turbine condenser or condensate surge tank. With a degasifier delivering water saturated with air some preferential deaeration in a steam pressure deaerating heater followed by cooling is required to remove higher amounts of oxygen. The vacuum deaerator eliminates the cost of such a steam pressure deaerator. This high pH water with less than 0.1 ppm oxygen is also less aggressive to metal and less expensive piping and storage material are generally required.

There is some evidence to indicate that lower oxygen of 0.1 ppm may somewhat increase the long term life and performance of the highly basic anion exchangers used in this process. Since these products run somewhat more expensive than other ion exchangers it is wise to take all precautions to prolong their useful life.

Mixed bed demineralizers produce demineralized water at a pH of 7.0 and vacuum deaeration or steam pressure deaeration is employed to reduce oxygen in this water before feeding into the system. Again the condensate surge tank or the turbine condenser represent the preferred points of demineralized water introduction, depending on such water temperature and other cycle characteristics. In some cases, small amounts of caustic soda are fed into the demineralized stream before the surge tank.

Chemical Regenerant Handling

Absolute dependability of service of all demineralizing equipment with minimum maintenance involves close attention to design and construction of regeneration equipment as well as valves, controls and instruments. Since handling of quantities of acids and alkalis sometimes on a daily or semi-weekly basis is a necesary part of demineralizer operation, foolproof design and construction of this part of the equipment is necessary.

Figs. 4 and 5 give two typical designs of chemical handling systems. Materials of construction are shown in Table II.

As for determining the estimated chemical operating cost of various demineralizing systems we recommend a six-step procedure. First step involves obtaining an analysis of water to be treated with results expressed in ppm as $CaCO_3$. The second step tallies from this analysis the total cations in ppm as $CaCO_3$. This total is the sum of the Ca^{++}, Mg^{++} and Na^{++} in ppm as $CaCO_3$. At the same time steps 3 and 4 are undertaken and the methyl orange alkalinity is obtained in ppm as $CaCO_3$. This data, in ppm of methyl orange, divided by total cations and multiplied by 100 gives per cent alkalinity, step 4.

A review of the raw water analysis and its proposed use constitutes step 5. This review determines if silica and CO_2 removal need be done. Finally, in step 6, the use of the curve, Fig. 6, produces approximate chemical operating costs in cents per 1000 gal. of net water to service.

There is a slight note of precaution to sound in the use of Fig. 6. You enter the curve along the ordinate with the data on total cations, step 2, above, and move over to the curve indicating alkalinity in per cent as calculated by step 4. But here is the note of caution. Be certain to use the correct series of curves as labeled in Fig. 6. Then drop down from this intersection point of per cent alkalinity with the curve showing total cations to read estimated chemical costs on the abscissa.

Automation of Operation

In general, there has been a greater and greater trend toward complete push button operation and regeneration of demineralizing units. The use of time cycle control mechanisms, such as Bristol Cycle Controllers, together with diaphragm operated rubber lined Saunders Patent

TABLE II—SUITABLE PIPING AND FITTINGS MATERIALS

Point of System	Characteristics Relative to Steel	Materials of Construction
Influent Raw Water	Not usually corrosive	Steel pipe in all sizes
Cation unit effluent	Acid—very corrosive	Plastic pipe in smaller sizes; plastic pipe, rubber-lined steel pipe in larger sizes
Anion Unit effluent	Low Solids, oxygen-corrosive	Plastic pipe in smaller sizes; rubber-lined steel pipe, plastic-lined steel pipe in larger sizes
Concentrated H_2SO_4	Mildly corrosive	Heavy-walled steel pipe
Dilute H_2SO_4	Very corrosive	Plastic pipe in smaller sizes; rubber-lined steel pipe in larger sizes
Concentrated and dilute hydrochloric acid	Very corrosive	Plastic pipe in smaller sizes; rubber-lined steel pipe, plastic pipe in larger sizes
Sodium carbonate	Not corrosive	Steel pipe in all sizes
Sodium hydroxide	Not corrosive	Steel pipe in all sizes

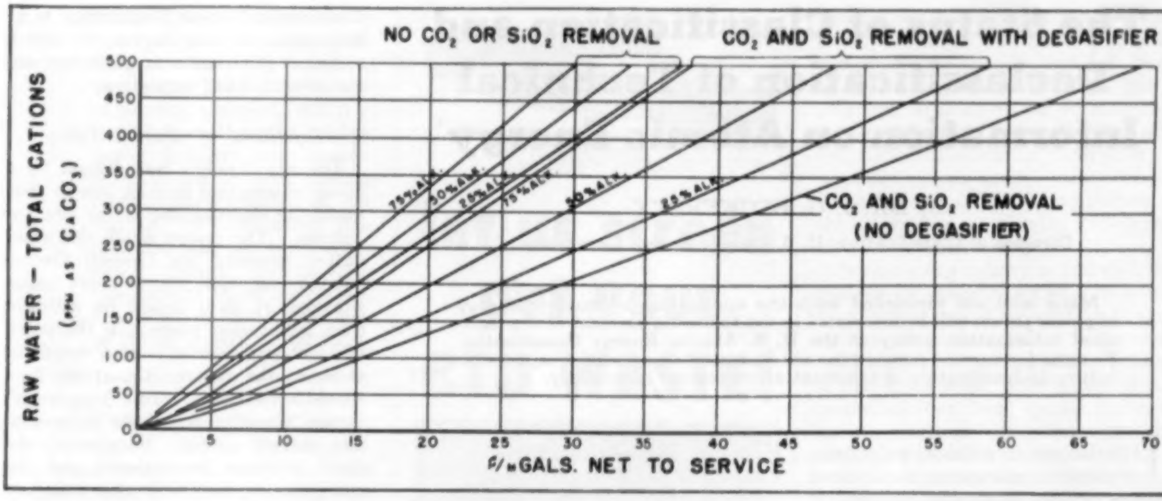


Fig. 6—Estimated chemical operating costs for various demineralizing systems can be picked off the above curves. The curves have been worked up using average chemical costs as of early 1954

Valves, for absolute drop tightness and lowest maintenance, has been the general rule. Dependability, foolproof service of many years with virtually no maintenance or outage is the reason for this.

Figs. 7 and 8 show typical performance curves from 2-bed and mixed bed units.

Primary control of regeneration in all demineralizing plants, generally without exception, comes from use of the substantially foolproof and simple conductivity meter. Wherever water does not meet conductivity standards, the demineralizer must be rinsed to waste for a preset time or regenerated after alarms are sounded.

Totalizing meters on the inlet and outlet from the various ion exchange units, particularly on waters of seasonally constant composition, affords a means of secondary control in many plants.

In some cases pH meters with proper sampling points control endpoints on cation units but this method is not generally applicable for primary control of operation or initiation of regeneration.

Silica tests, generally run gravimetrically, are performed once or twice daily in some power stations for record purposes. In the main, however, silica stays well within the guaranteed limits as long as the conductivity of the treated water is below the required value as per Figs. 7 and 8.

Flow line type lighting on preassembled panel boards has been employed in several utilities, particularly where mixed bed units are employed such as at Shawville Station of Pennsylvania Electric Co. The latest designs of these preassemled panel boards present an attractive addition to the boiler house.

With the above indications of proper instrumentation, reliable automatic operation and push-button panel board assemblies the demineralizing plant has definitely reached a comparable performance level with the other major elements in power plant practice. And in keeping with the experience of these other elements, future progress will result from improvements in the materials involved, as well as from advances in the techniques of application and operation.

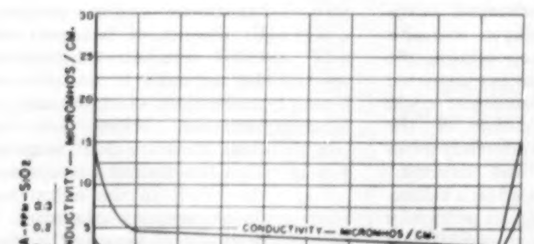


Fig. 7—Two-bed silica removal demineralizing system shows that performance changes sharply as silica breaks through, conductance drops momentarily and then shoots up rapidly as shown

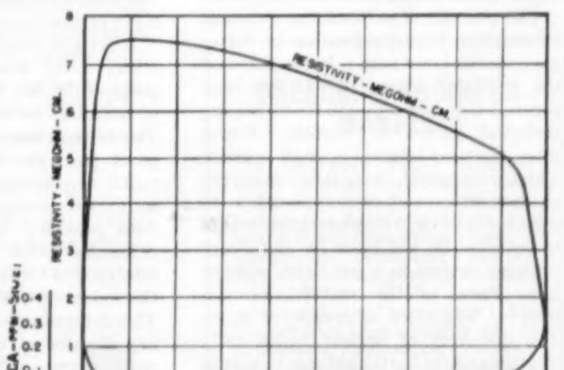


Fig. 8—Mixed bed silica removal demineralizer shows the same general performance characteristics. Electrolyte removal is so complete curve is plotted in terms of resistivity rather than conductivity

The Status of Classification and Declassification of Technical Information on Atomic Energy*

by DR. J. G. BECKERLEY

Director of Classification, U. S. Atomic Energy Commission

Many who are concerned with the application of nuclear energy to power plants will be interested in the following account of the technical information policy of the U. S. Atomic Energy Commission. Reasons for current restrictions are discussed along with prospects for future declassification of information on reactor technology.

THE decision to withhold publication of technical information is not direct action against unfriendly nations. It is a very limited defensive mechanism. Withholding information does not prevent others from developing the same information by their own efforts. This must be continually borne in mind. Secrecy is a passive technique. Moreover the limitations of the assistance afforded by access to technical information should be understood. A sketch of a plutonium chemical separations process is only a piece of paper; to translate it into an operating plant requires many man-years of effort, perhaps more ingenuity than went into the original process sketch. Information about a device is not the device itself. This is obvious, but often missed in popular discussion. To many persons the phrase "handing out our secrets" implies the furnishing of things, not information; the word "our" in the phrase implies exclusive possession—we have them, the only secrets in the world.

I dislike repeating such simple notions but I have observed much confusion where these simple ideas are forgotten.

The practice of withholding technical information from publication or delaying issuance is not new. Information on the technical devices of war has been controlled in proportion to the increasing technical nature of warfare. Nowadays, the time interval is small between a highly technical, "long-hair" discovery or invention and its application to military devices. Fundamental ideas of today may be the basis for significant military devices in a few short years or less. Prior to the mid-thirties this interval was often a decade or more. The discovery of nuclear fission early in 1939 and its battlefield use in a militarily decisive device in mid-1945 is indicative of the speed of military application of fundamental scientific information.

Information Control

Because of this trend toward telescoping basic research and military applications, there has been an increase in the practice of "information control" on non-weapons data. The most striking example of the use of secrecy in technical matters was the setting up of "restricted data" by the Atomic Energy Act of 1946. In addition to classifying, i.e., withholding publication and safeguarding information on the design and manufacture of atomic weapons, the Act designated as restricted data "all information concerning . . . the manufacture of fissionable material and the use of fissionable material in the production of power. . . ." Now fissionable material is essential to an atomic weapon. If you do not have the fissionable material, you can't make a bomb. On the other hand, if you have the fissionable material, you do not have to make a bomb. The swords or plowshares choice is yours. In fact the choice is even more striking—fissionable material can be used for weapons or it can be used as a basic source of energy. The peacetime use is not a trivial luxury; it is a primary natural resource.

It is eight years now since the Atomic Energy Act was adopted. The language of the Act, as it pertains to control of technical information, is unchanged. The interpretation has changed. Congress gave the Commission exclusive right to declassify, i.e., remove the security restrictions, from any restricted data provided the Commission could determine that publication of the information "would not adversely affect the common defense and security." This determination is based on a balancing of value of the data to unfriendly nations versus value to our own national technical efforts. With this authority to declassify, the Commission has over the past eight years released a large body of technical data, withholding only that which in its judgement would be of substantial use to a potential enemy. The scope of the International Congress on Nuclear Engineering is an indication of the degree to which technical publication is permitted under present AEC regulation.

Definition of Initial Policy

The initial policy was defined by a group of scientists meeting late in 1945 under the chairmanship of the late Dr. Tolman. The report which this committee prepared for General Groves pointed out that for a short range situation all data should be withheld from publication whereas, if the possibility of war were at least a decade or more in the future, almost all data should be published. This "long range" versus "short range" choice is basic to any secrecy policy. Because of the great post-war uncertainties and the emergence of the USSR as a definitely unfriendly power, the Commission had to take an intermediate position, actually tending toward the short range policy. Under this policy all basic scientific non-weapons data were released and so-called "technology" withheld. This meant, for example, that laboratory studies of basic chemistry of plutonium have been published but information on our large scale plant experience in producing plutonium has been kept classified. In the field of atomic weapons this policy has been narrowly interpreted. "Basic" data are usually interpreted as ultra-pure theoretical information, such as new mathematical techniques.

Since the Russian atomic weapon test of late 1949, this policy—hold technology, release basic scientific information—has been slowly changing. At the present time it is apparent that a restrictive policy on the publication of non-weapons technology is of questionable value. Two important factors must be considered:

1. *USSR Advances.* The policy for controlling non-weapons as well as weapons data has been based for several years past on the desire to avoid any possible assistance to the USSR in her atomic weapons program. By August of last year the USSR demonstrated that she did not need to wait for our publication of technical information before achieving even thermonuclear weapons. This demonstrated progress of the USSR in the fission and fusion weapons arts tends to destroy confidence in the effectiveness of secrecy.
2. *Nuclear Power.* The remarkable progress and increasing optimism of the past few years in the development of power reactors indicates that a thriving basic industry is being born.

* Presented at the International Congress on Nuclear Engineering sponsored by the American Institute of Chemical Engineers, Ann Arbor, Michigan, June 21, 1954.

While it may prosper in its first years on controlled information and while it may not be handicapped by the harness of security practices, still it is doubtful whether the nuclear power industry can become fully grown without casting off the paraphernalia of the toddler. In other words, it is doubtful whether the nuclear power industry can develop full strength under the present conditions of information control set by governmental fiat.

These facts have been recognized by the Commission. At first, in 1950, essentially all data on research reactors were published. During the intervening years more and more has been published about what can be done in a technical way with power demonstration units. At the present time there is still a very large body of classified reactor information, consisting principally of: (1) technical details on how to fabricate reliable reactor fuels, (2) performance data for nuclear fuels operated at elevated temperatures and in intense radiation fields, (3) the technology of separating plutonium and uranium from irradiated fuel elements, (4) an assortment of nuclear knowledge useful to power reactor designers. This body of classified information will be reduced in time, for it is the AEC's publicly stated policy to declassify reactor data as national activity in the field increases.

Effects of Declassification Policy

The dangers of an overly restrictive declassification policy are not generally recognized. Any broad national participation in the technical activities relevant to nuclear technology is possible only if a substantial body of information is in the public domain. Classified reactor information, for example, can be disseminated only under strict security safeguards and, although such dissemination can be on substantial scale, it is a slow and expensive process. Moreover, it is hardly consistent with free competitive enterprise since it is a government controlled activity. This slowdown in the flow of technical information cannot be ignored and passed off as "necessary for the national security." Rapid development of nuclear power is in itself a part of our national security.

One aspect of the dangers of too much secrecy in non-weapons matters is that too restrictive circulation of technical data results in too few trained minds and hands. If only a few heads share the "secrets" of nuclear power, there will be only a correspondingly few hands to build new machines. An expansion in such an activity as manufacture of nuclear plants [illegible]arines would be greatly retarded for lack of trained personnel. During the first few years of the Commission's program, many jobs were delayed by the requirements for on-job training. Now, because of a rational declassification policy, it is possible to minimize such delays. Basic training is now accomplished at the universities, engineering schools and at technical conferences.

We are going to have to live with the nucleus for many centuries. It would be a happy time if we could just shut up the whole business in a box and open it up at some time when we have achieved national and international maturity. But we cannot. Consequently, instead of boxing up the relevant technical information we must bring it out in the open. In this way the exploitation of the atomic nucleus for mankind's benefit can proceed at an increasing pace.

To put the problem in specific form, have we not now reached the stage in atomic development where we should release essentially all our technical data except that concerning the design and manufacture of the weapons themselves? This would be a return to the usual pattern of secrecy where devices are classified and not the widely useful components of the devices.

I recognize that limiting atomic secrecy to purely weapons information is a matter for future action. There will need to be considerable public discussion and possibly some Congressional action before the Commission could undertake such a program. However, I should like to predict that, just as it is inevitable that competitive nuclear power will be developed, so it is inevitable that peacetime non-weapons technical information will in time be essentially completely unclassified.

Engineering Educators Stress Fundamentals

ENGINEERS should become more scientific, more creative and more human. This evaluation of current engineering education was the dominant theme of the 62nd Annual Meeting of the American Society for Engineering Education held June 14–18 on the Urbana-Champaign campus of the University of Illinois.

More than 1600 engineers, mostly teachers from colleges in every state of the union and many foreign countries, registered for the meeting. They urged each other to devote more time to the basic sciences, engineering science, and the humanities—at the expense of engineering art or practice.

Industrial employers, generally agreeing with the educators, said that they were unwilling to have colleges sacrifice the sciences and humanities to provide time for studying technology or administration. They insisted that their sales, manufacturing and operating departments (as well as their research and development divisions) need engineers with strong scientific backgrounds.

The extent of this move to strengthen science is shown by the proposal in an interim report of the ASEE's Committee on Evaluation of Engineering Education. This proposal would have all engineering students—whether majoring in chemical, mechanical, electrical, civil or other branches of the field—study in common almost five-sevenths of the total course. Only two-sevenths would be concentrated in the field of the major, and almost half of this as electives.

In his principal address of the meeting, **Dean L. E. Grinter** of the University of Florida, retiring president of the ASEE, said that colleges "must experiment with all possible methods of orienting engineering education more significantly toward basic and engineering science." He added that the greatest weakness of engineering education has been insufficient attention to integrating practice and specialized science so that students can understand the rules of engineering through their scientific knowledge. Dean Grinter said that the engineer must be inherently creative, putting together a combination of theories, concepts, techniques and experience in new patterns.

The emphasis on science was continued by **Dr. Lee A. DuBridge,** president of the California Institute of Technology, who spoke at a celebration of the fiftieth anniversaries of the engineering experiment stations at the University of Illinois and at Iowa State College. "Maintain a close tie with the basic sciences," was Dr. DuBridge's advice. "An engineer, after all, is putting to practical use today what scientists discovered yesterday." Still more important, Dr. DuBridge stressed, is the fact that the work he must do tomorrow will grow out of what the scientist is on today.

"The main purpose of science," said Dr. DuBridge, "is not to produce bombs and guns and radar—or even radios, refrigerators and color TV, but to advance human understanding."

Despite the high purposes of science, too few high school students are being led to a study of science according to **Major Lenox R. Lohr,** president of Chicago's Museum of Science and Industry. Major Lohr told the attendants at the annual banquet of the Society that only 4 per cent of Chicago high school students are studying physics and no more than one-half per cent are studying solid geometry. "Uninspired and inept instruction have too frequently made these all-important subjects a nightmare for the student," Major Lohr said. "The teacher should emulate the good salesman—be convinced of his subject's importance, know that his student has a vital need which he can supply, and induce the student really to want it by employing those devices which make it most palatable and persuasive."

Engineering Manpower

A report based on a survey conducted by the Engineering Manpower Commission of the Engineers Joint Council provided information on the current demand for engineering graduates. It was concluded that the decline in business activity and defense orders in 1954 has led to a decrease in the requirement for engineering graduates of about 20 per cent. Yet despite this decrease, there is still a substantial unfilled demand.

Power Option in Electrical Engineering

A series of papers was presented on various phases of training power engineers through the power option in electrical engineering curricula. **Dean W. A. Lewis** of the graduate school of Illinois Institute of Technology evaluated areas in which the electric power industry is losing and gaining ground. He stated that in many fields of transportation electric energy has been losing the competitive battle, whereas it has been gaining in those applications where energy control in response to human or automatic evaluation of the need is the factor of prime importance. There should be an awareness of the competition between electric power and other forms of supply, and the future electric power engineer must be trained to be prepared for radical change, if and when it comes. Dean Lewis added that it is conceivable that a small reactor can be developed that can be installed in the individual home or small plant. If simplified controls are applied, the unit would be capable of supplying energy needs for many years without additional fuel or replacement of major components. If such a power source comes into being, it would almost eliminate any need for electric transmission and distribution systems. To meet such an eventuality, Dean Lewis contended that the electric power curriculum must be adaptable and provide sound fundamentals.

Prof. H. A. Peterson, chairman of the electrical engineering department of the University of Wisconsin, traced the dynamic growth of the electric power industry and concluded that some of the best engineering talent will be required to fulfill the needs of continuing expansion programs. Instead of discontinuing the curriculum in power, means must be found of reversing the trend which now finds both student and faculty interest at a very low point. Part of the educational task toward a renaissance of interest lies in developing an interest among teaching staff members of the opportunities in the broad field of power.

Commenting on opportunities for young graduates in the power field, **Prof. J. A. M. Lyon** of Northwestern University observed the colleges do not wish to teach men to do routine industrial jobs. He urged those responsible for developing engineering personnel to avoid emphasis on knowledge of equipment and to make use of special abilities possessed by recent graduates instead of limiting their vision by keeping them too long in sub-professional jobs. To train for the future, electrical engineers should be taught fundamentals of nuclear processes. For a power curriculum, additional elective courses in nuclear reactors and nuclear instrumentation seem desirable.

On the industrial side of the picture **S. B. Crary** of the General Electric Co. discussed essential requirements for power system engineering, observing that colleges can best provide the basic training and industry the specialized training. What concerns the power industry is that, with the

exception of several schools having power system engineering faculty, very few engineers are being trained in this speciality. Among the specific training which should be provided is the study of system and circuit analysis, use of symmetrical components and various types of analyzers and study of transient phenomena, rotating machinery and system stability.

George M. Keenan, director and vice president of the Pennsylvania Power & Light Co., stated that the work done by engineers in an operating electric utility covers such a broad range that opportunities for an engineering graduate are practically unlimited. He set forth eight elements of education for all engineers to have.

1. A sound *foundation* in and *knowledge* of the political organization of the United States at the federal, state and local levels, and of the American economic system.
2. A knowledge and realization of the necessity of working with and thinking of other people.
3. A basic knowledge of the fundamentals of business organization, labor relations and personnel administration.
4. An ability to organize his work and an appreciation of the value of time. Schedules must be met, decisions must be made, work must get done, not just started.
5. An appreciation of values in terms of the dollar no matter how inflated or deflated. We call this cost-consciousness.
6. A sound foundation in engineering mathematics, engineering physics, engineering chemistry, dynamics and the properties of engineering materials.
7. A broad knowledge and understanding of the language of engineers.
8. The ability to analyze problems, think clearly and express the thoughts logically, both orally and in writing.

Discussion

There was considerable discussion, much of it centering about the extent to which both student and faculty interests have shifted in the direction of the electronics option. In some schools, the percentage of electrical engineers selecting the electronics option is reaching as high as 90 per cent. One professor explained this trend on the basis that nearly all students must enter the armed forces, and there a knowledge of electronics proves of immediate and definite help.

There is also a wide-spread feeling that little additional research is necessary on electrical machinery and that this area has lost its challenge.

On the other hand, **Dean L. V. Bewley** of Lehigh University expressed the opinion that there is a more natural marriage between the electrical engineering power option and mechanical engineering than between the power and electronics options within electrical engineering. In his opinion the future of electronics is more closely allied with physics than with the power option of electrical engineering. There is need to break down the idea that power engineering is passé and to find more faculty members who have had a power background and genuine enthusiasm for the field.

Creativity in Engineering

M. S. Gjesdahl of the mechanical engineering department of The Pennsylvania State University observed that one of the basic requirements for consideration of education for creativity is an uninhibited mind. Also, a sense of dissatisfaction with routine procedure is helpful. He described a course in applied machine design in which a term design problem was assigned and the students were required to justify and clarify the design before a panel of three faculty members. The latter evaluated the design on the basis of originality and presentation, engineering design and production.

Undergraduate Mathematics

In a paper entitled "A Report on One Current Effort to Revise the Undergraduate Program in Mathematics" **Prof. G. Baley Price** of the mathematics department at the University of Kansas stated that the Mathematical Association of America had appointed a Committee on the Undergraduate Program at a meeting late in 1952. This Committee has agreed that a revision of the undergraduate curriculum is desirable.

New Books

Any of these may be secured by writing Combustion Publishing Company, 200 Madison Avenue, New York 16, N. Y.

Fresh Water from the Ocean

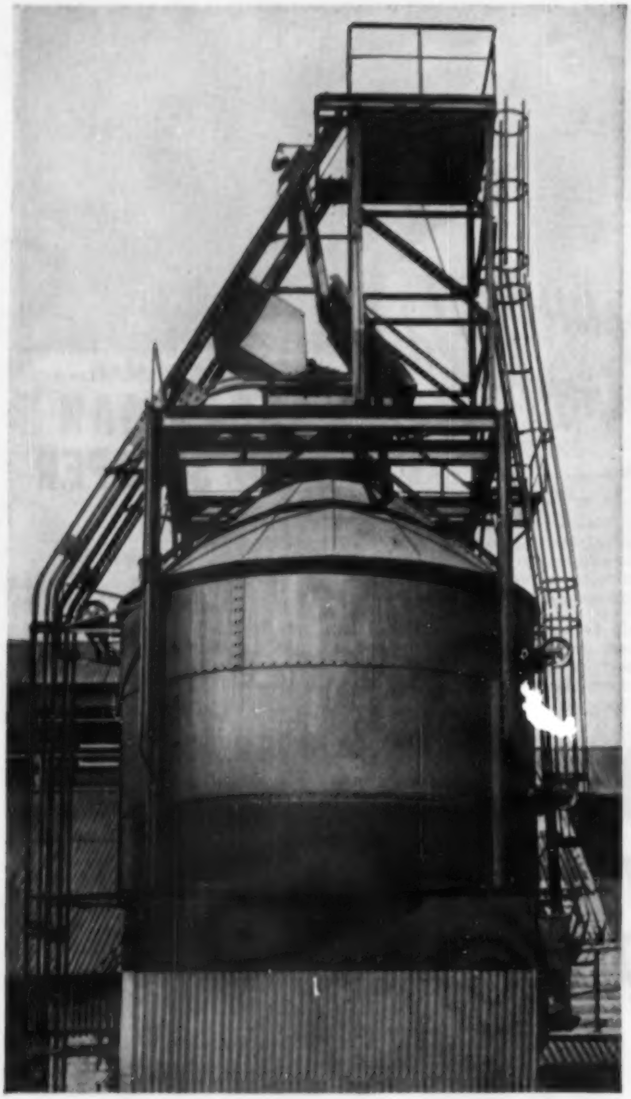
By Cecil B. Ellis

Sponsored by The Conservation Foundation, this book deals with problems of water supply that will have to be solved within the next few decades. The author, assisted by members of the staff of Nuclear Development Associates, Inc., investigated the prospects for salt-water conversion in projected capacities of 1000 million gallons per day. A project of this size would be capable of irrigating about 200,000 acres of farm land or of supplying the daily needs of New York City. Theoretical power requirements for this quantity of fresh water are 108,000 kw, and an actual installation of about 1,000,000 kw would be required.

The wide range of processes investigated and the evaluations placed upon them by the author combine to make this book most fascinating reading. Among the processes and methods considered are electrolysis; magnetic-electric membranes; mechanical effects of pressure, vibration and rotation; effects of heat and rotation; liquid-surface and solid sieves; biological and charged-net membranes; electro-osmosis; multiple-effect, compression, super-critical and solar distillation; and such chemical techniques as precipitation, adsorption and ion exchange.

By the nature of the subject much of the material in this book is highly speculative. But because it concerns a long-range problem of water supply and involves very substantial amounts of power, many engineers in the power field will find it of interest.

There are 217 pages in the book which sells for $5.



Fly Ash Problem Solved By Central Station

This Pennsylvania utility felt that as long as you can *see* dirty stack discharge, you have a problem. To solve it, they decided to insist on fly ash collection equipment with very high efficiency.

The electrical precipitators they chose, which were placed after existing mechanical collectors, are Cottrells, designed and built by Research Corporation. Their effectiveness is demonstrated in the above unretouched photographs. At the left, the precipitators were turned off long enough to take the picture showing the volume of fly ash discharged by the boilers. At the right, the precipitators are turned back on. Stack discharge is visually clean.

This is another example of industry's trend toward establishing its own higher standards for nuisance abatement. Research Corporation, which has made more fly ash installations than any other company, cites the following comparison:

In the period from 1923 to 1939 only 11% of its power plant customers specified fly ash collection efficiency of 95 to 98%. In recent years, that 11% has risen to fully 90%.

One reason, of course, is the generally increasing emphasis on community relations. Another factor is that far-sighted companies are anticipating stricter smoke regulations. They are anxious to install equipment that will end their smoke problems now and also prevent such problems from occurring in the future.

Still another factor is this. In recent years, with modern coal pulverization and advanced boiler design, there has been an increase in the fineness of fly ash particles. This calls for the most efficient equipment available.

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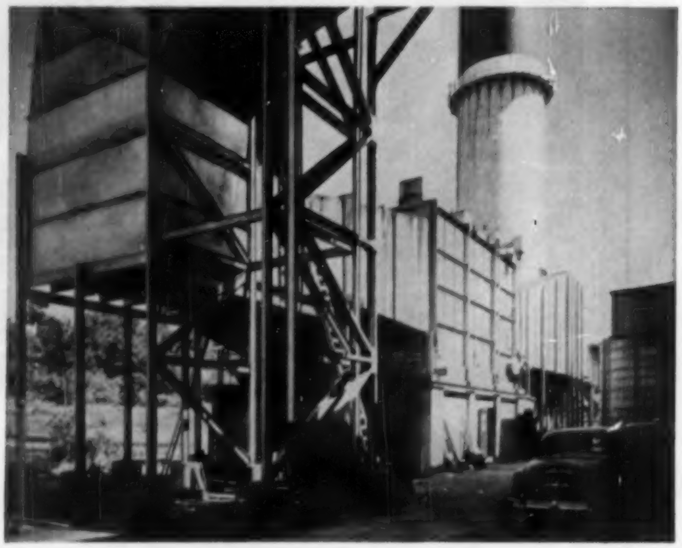

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